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MACHINE DESIGN

A PENTON PUBLICATION

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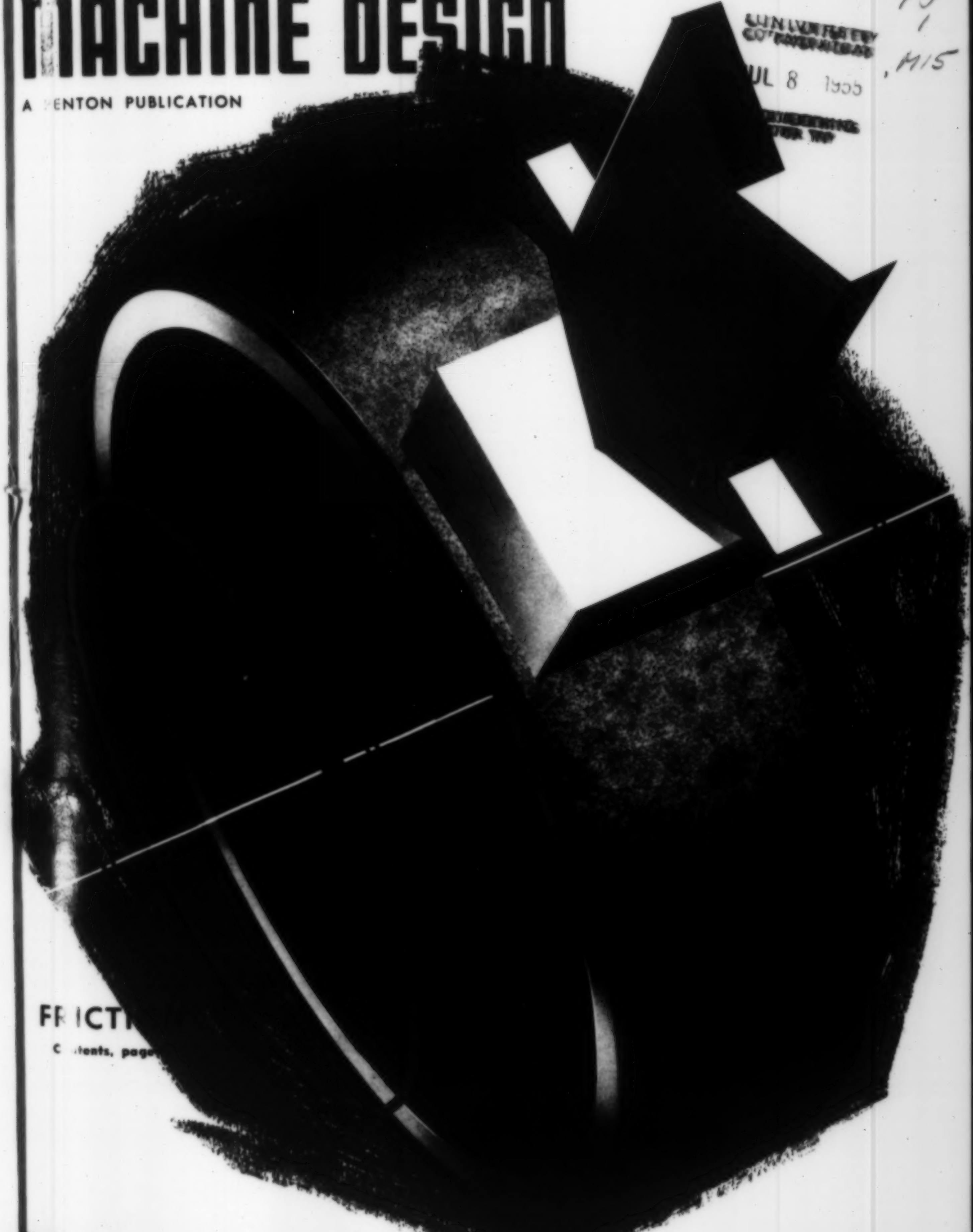

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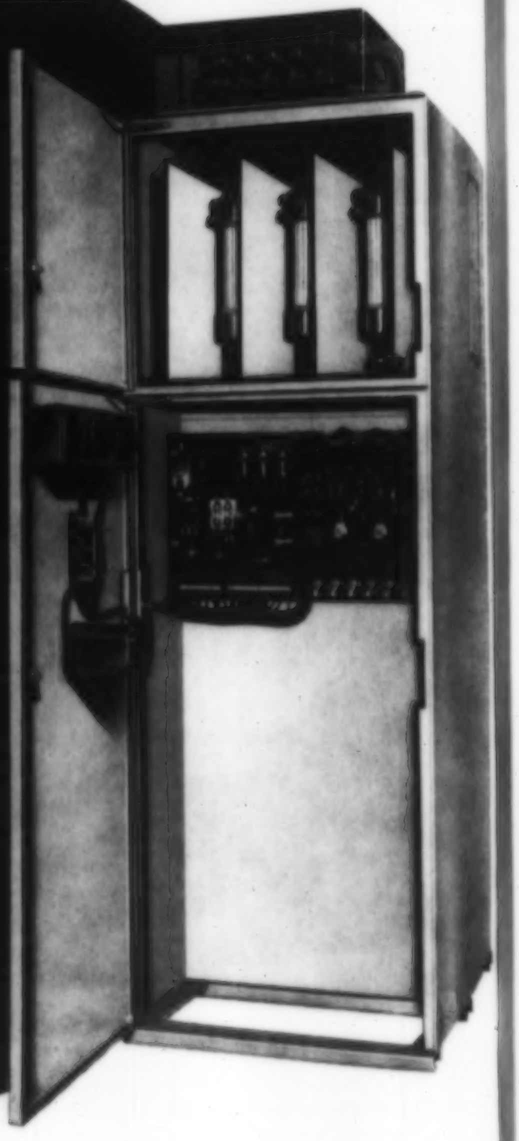
Allis-Chalmers offers a complete line of **MOTOR CONTROL**

Small ... Large and all sizes in between



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An Allis-Chalmers recommendation is backed by the experience gained in solving thousands of control application problems . . . by complete research and testing facilities. Get all the facts. See your A-C representative or write Allis-Chalmers, Milwaukee 1, Wisconsin.

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ALLIS-CHALMERS A-C ALLIS CHALMERS

THE PROFESSIONAL JOURNAL
FOR ENGINEERS AND DESIGNERS

MACHINE DESIGN

JULY 1955
Vol. 27—No. 7

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Over the Board

Stroking a Cat

One of the interesting facts brought out in J. B. Mohler's article on shaft finish, Page 132, is the effect of graphite flakes in a machined cast iron shaft. It seems that sometimes slivers of metal can overlay the graphite flakes, and the slivers all point in one direction because of the direction of grinding. So when the shaft is run in a bearing, it's perfectly satisfactory when rotating in one direction, but causes plenty of trouble if rotated in the opposite direction. As one of our editors remarked, "Just like stroking a cat the wrong way."

Bebop Bugler

One of our editors recently had occasion to stay overnight at an Army post, and was awakened from a sound sleep the next morning by a bugler blaring out "Reveille." "What a man," he thought and, being an editor and not subject to Army regulations, turned over for another forty winks. What a disappointment, though, when he found out later that the bugler—like many other craftsmen—has succumbed to the influx of automation.

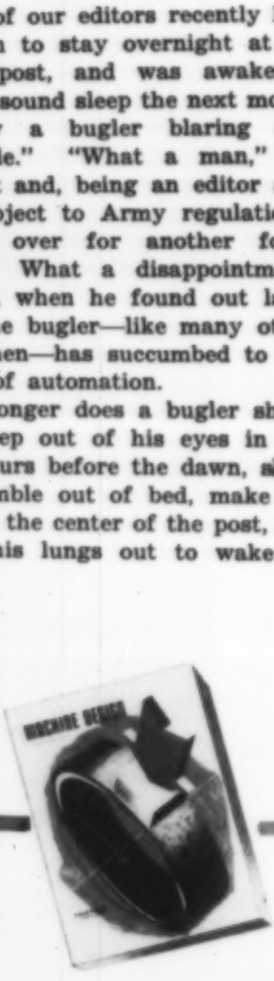
No longer does a bugler shake the sleep out of his eyes in the wee hours before the dawn, slowly stumble out of bed, make his way to the center of the post, and blast his lungs out to wake up everyone else. No, now it's done with records; "Reveille" is just a recording played over the loudspeaker.

We understand that the armed services are considering establishing a new technical specialist rating—"disk jockey, first class." Can't you just imagine the new Army situation:

"Good morning, good morning. This is Hy Fidelity, your favorite disk jockey first class, bringing you an early morning program sponsored by your Army. First on the program this morning is a rock-and-roll recording of that ever-popular favorite, 'Reveille,' done by Sergeant Sam Swing and his Three Stripes. And later we've got a new mambo version of 'Mess Call' . . ."

This Month's Cover

If friction didn't exist, just think how much easier and less expensive it would be to design a machine. No bearings, no lubrication and reduced power input are all possible advantages. But wait a minute! Friction is necessary, no matter how hard we work to get rid of it in certain design areas. How would you ever stop an automobile without brake friction—or get one moving without friction between the tires and the road. Howard Huntress' article on friction fundamentals, Page 151, the first of a group of articles on friction, friction materials and friction mechanisms, points out some of these factors. It also serves as a keynote theme this month for George Farnsworth's cover on friction.



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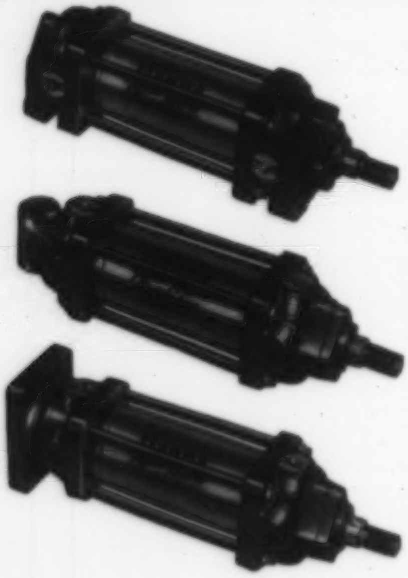
HANNA AIR and HYDRAULIC CYLINDERS



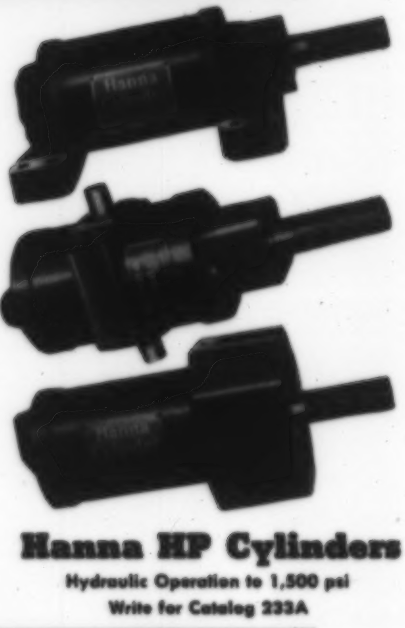
Hanna T750 Fluid Power Cylinders
Air Operation to 250 psi, Hydraulic Operation to 750 psi
Write for Catalog 750A

Hanna LP Cylinders
Air or Hydraulic Operation to 110 psi
Write for Catalog 236

Here's Everything You Need
Smooth, Dependable Power
Packaged As You Want It

"Good things come in small packages," it is said . . . so do Hanna Cylinders . . . and in medium and large packages, too. From the complete Hanna Cylinder line, up to 1,500 psi capacities, you can select a standard size and mounting style, with the power and stroke you need, to exactly suit your applications. Of course, you will be sure it's the finest cylinder for the job—because it's a Hanna. Well over fifty years of design and manufacturing experience guarantee that.

So, when you need reliable cylinders for products you make for resale, or for use in your own plant, consult a Hanna representative, or call on our plant engineers to help you find the most efficient answer to your problem. Also write us for technical literature.

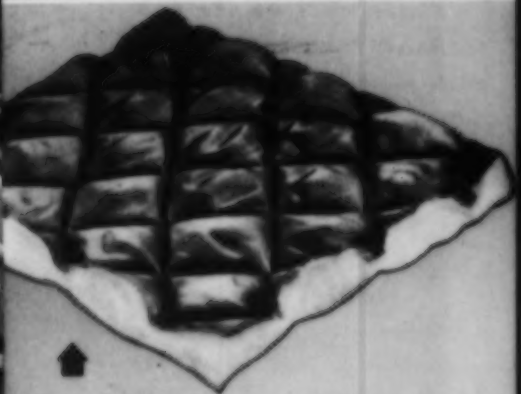


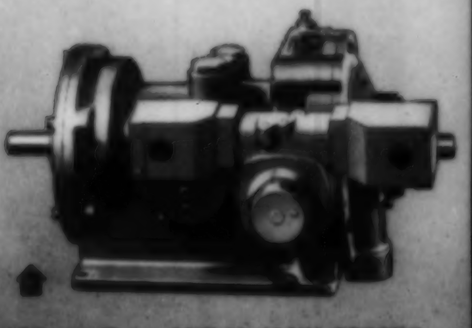
Hanna HP Cylinders
Hydraulic Operation to 1,500 psi
Write for Catalog 233A

Hanna Engineering Works
1751 Elston Avenue, Chicago 22, Illinois

WITH OILGEAR "ANY-SPEED" REVERSING DRIVES—PRODUCTION WENT UP

Close-up of battingmachine as changed over to an Oilgear "ANY-SPEED" Drive. Performance was so greatly improved, Star Woolen Company have installed Oilgear on a second identical machine.


NY-SUL-LITE (nylon batting) material manufactured by Star Woolen Company and used in famous make sports jackets, snow-suits, and comforters.


Oilgear Type AXB-33 "ANY-SPEED" Fluid Power Transmission Drive.

A 26% INCREASE FROM SMOOTHER REVERSALS. OILGEAR PAYS FOR SELF IN ½ YEAR.

t one of the many advantages of Oilgear NY-SPEED" Drives is highlighted re. The Star Woolen Company of hoes, N. Y., operates cross-lay batting chines. Original equipment included eather belt and clutch reversing de- e because manufacture of the prod- requires cross-laying of nylon fibre wool at periodic intervals. Reciproca- n occurred a maximum of 22 times a nute. The going was so rough that the chine was frequently down.

When Star Woolen Company installed Oilgear Reversing Transmission ve, the improvement promised was mediate, and other advantages be- e apparent. The Oilgear drive cushioned acceleration and deceleration so smoothly that mechanical failure dropped sufficiently to give them 15% more production from that one factor alone. The speed of operation has been increased to 30 reversals a minute; operator can select "ANY-SPEED" from zero to maximum; positive, fast-acting electro-hydraulic control through manual push-buttons or automatic switches gives them a far more versatile machine, enabling them to handle jobs hitherto denied them. The Oilgear "ANY-SPEED" drive paid for itself in 6 months, out of savings in machine operation alone.

Smooth acceleration, deceleration and reversal, infinitely variable and completely controllable speeds are just part of the Oilgear "ANY-SPEED" Drive story. Don't you want to know the rest of it? It has proved extremely profitable in scores upon scores of machine applications. Write today and tell us something of *your* needs. THE OILGEAR COMPANY, 1568 West Pierce Street, Milwaukee 4, Wisconsin.

OILGEAR
Fluid Power

PIONEERS . . . NOW THREE PLANTS
FOR FLUID POWER

PUMPS, MOTORS, TRANSMISSIONS, CYLINDERS & VALVES

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NEW DEPARTURES OF TOMORROW

Valet-mat—
1960?

It could well be that in less than a decade a compact new appliance for the home will clean and press a suit, coat or dress in seconds.

Of course, such a machine is yet to be developed. But one solid fact: when the "Valet-mat" does arrive, it will probably be New Departure ball bearings that keep it operating smoothly and efficiently.

Today, practically any type of home-service product you can name is New Departure-equipped. So, when your thoughts turn to new departures of tomorrow . . . think of New Departure—the company that makes the great forward strides in ball bearing design and manufacturing.

NEW DEPARTURE • DIVISION OF GENERAL MOTORS • BRISTOL, CONNECTICUT

Versatile, easy-to-operate machines that take the backache out of "ironing day" are a housewife's dream come true. And manufacturer after manufacturer has called on New Departure for its ball bearings.

NEW DEPARTURE
BALL BEARINGS

NOTHING ROLLS LIKE A BALL

Engineering News Roundup

Electrical Contacts Wedge Together

Taper Principle Eliminates Connector-Wire Soldering

Taper-pin principles have been applied to electrical connectors to eliminate soldering and save space. In addition, the taper principle application is said to save connector assembly time and reduce the possibility of wiring failures.

Developed by Aircraft-Marine Products Inc., the technique consists of fastening a tapered pin to the end of the wire and forcing the assembly into a mating hole. Taper angle of the pin and hole is controlled to give high contact pressure. Excellent electrical conductivity is said to result from the connection.

Solder failures occurring in AN connectors prompted the new development. Wires breaking at the solder pots of contact pins was said to be one major difficulty. Another problem occurred when soldered contacts were used in high-temperature areas. Both these difficulties are claimed overcome with the new solderless connections.

Taper-pin connections are also said to save assembly time. Tedious and sometimes delicate soldering operations are eliminated. Along with the elimination of solder, a weight saving is also experienced. A further advantage claimed for taper pins is that more contact pins may now be crowded into a smaller space.

Comprehensive tests recently completed by a group of aircraft manufacturers indicate probable approval of the technique for military aircraft use. Tests included electrical resistance, pull-out, vibration, corrosion and electrical noise. Tentative results are reported to meet all government specifications for AN connectors. Taper pins are said to have already been approved for other government and commercial applications.

MORE ALUMINUM than ever is being used in 1955 passenger cars, according to this display. Shown here are 70 lb of parts used in the 1955 Chrysler New Yorker. Average for the industry is reported to be about 30 lb per car. This totals to an expected 178 million lb of aluminum to be used in the automotive industry this year

Standard AMERICAN flexible connectors like these may solve your problem . . .

If not, we'll design a "special" at no extra cost

What's your connector problem? Vibration? Movement? Misalignment? Cramped space? Want help solving it? Tell us what material you have to convey, temperatures and pressures involved, kind of end fittings you need, and the special conditions which will affect service. Our engineers will be glad to work with you. *The American Brass Company, American Metal Hose Branch, Waterbury 20, Conn.* In Canada: *The Canadian Fairbanks-Morse Co., Ltd.*

55178

WHEREVER CONNECTORS MUST MOVE

AMERICAN

flexible metal hose and tubing

an ANACONDA® product

M

FREE CATALOG . . . 16 pages of data on the com
plete line of American Flexible Metal Hose and Tub
ing, including fittings. Mail coupon to The America
Brass Company, American Metal Hose Branch
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CITY..............................ZONE....STATE..........

ROUNDUP FEATURE REPORT

Research Promises More Sun Energy Use

New Devices Show Solar Engine Development

Solar energy, available for the asking, has been the object of much research. According to a recent Stanford University report, the coversion of sunlight energy into something useful is extremely difficult. However, because of the attraction of getting something for almost nothing, thermodynamic engineers are devising more efficient ways of utilizing sunlight.

According to the report, the roof of the average house in the United States intercepts about 500 times more energy than the electricity used in that home. The accompanying table compares the amount of energy received from sunlight at various parts of the United States. Several methods are presently being used to convert some of this energy.

Average Solar Energy Received at Selected Cities

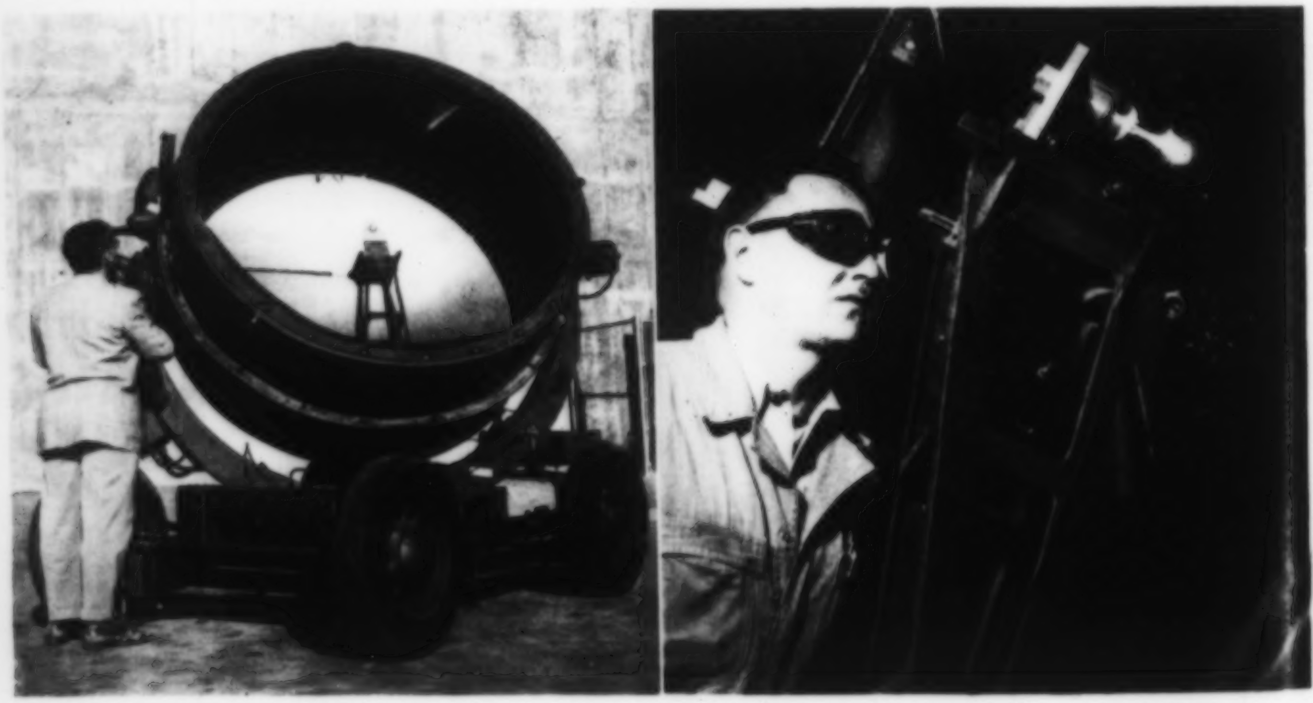
	Heat Energy (Btu/sq ft/day)	Electrical Energy (Kwh/sq ft/day)
Boston, Mass.	1110	0.336
Cleveland, Ohio	1312	0.385
El Paso, Tex.	2037	0.596
Fresno, Calif.	1670	0.489
La Jolla, Calif.	1526	0.446
Las Vegas, Nev.	1822	0.534
Lincoln, Neb.	1354	0.397
Miami, Fla.	1497	0.439
New York, N. Y.	1064	0.308
Salt Lake City, Utah	1442	0.420
Seattle, Wash.	1160	0.340
Washington, D. C.	1234	0.361

Flat-Plate Collector: One method of obtaining heat from sunlight is by a flat-plate collector. Here, light passes through glass and is converted to heat by objects under the glass. Since glass passes short or light waves but will not pass reflected long heat waves, the heat remains entrapped.

Heat from the flat-plate collector may be stored by water, stones or chemical materials. When needed, the heat may be withdrawn by fans or pumps. Hot gas or liquid may be used to drive heat engines for light service. Pumps driven by solar engines are commercially available in sizes from 1/10 to 3 hp. They are reported successful for pumping water in sunny, fuel-scarce areas. However, since the water being pumped is part of the condensing cycle, it must be relatively cool. Tests indicate that pump efficiency falls off rapidly with water warmer than about 65 F.

Maximum theoretical efficiency of a solar engine can be computed to be about 32 per cent. In actual practice, efficiency has been found to be less than 16 per cent.

Mirror Collectors: Solar furnaces developed for industrial use are of the mirror type. A series



Converted Army searchlight, left, is being used as a solar furnace for high-temperature testing of metals and other materials used in aircraft. Designed by Convair Div. of General Dynamics Corp., the furnace is capable of producing temperatures up to 7000 F at the focal point. An ordinary drill chuck, right, has been adapted to hold the specimens

LUKE THE LUBRICATOR

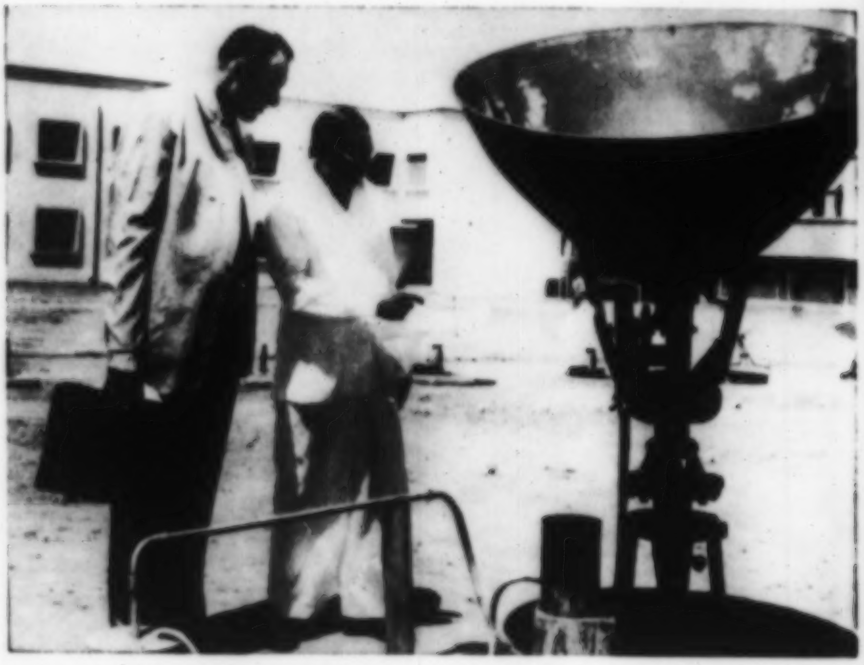
HOW TO BUY BEARING INSURANCE

This Kane & Roach Double Rolling Mill, used for forging steam turbine blades, is fully insured against lubricating troubles. The bearings, which operate under terrific pressures, are provided complete, positive lubrication by a TRABON Automatic Lubrication System.

With this installation, as with all TRABON installations, the operator will never have to worry about breakdowns due to improper lubrication. TRABON does the job automatically while the mill is operating under full load. All bearings are lubricated correctly. No loss-time with hand lubrication. The entire system is sealed against dirt, dust and all other foreign matter that can be ruinous to bearing surfaces.

There's a TRABON system for every lubrication problem. For further information on how *you* can get bearing insurance, write for bulletin 529.

Trabon ENGINEERING CORPORATION
1814 E. 40th STREET • CLEVELAND 3, OHIO
Oil and Grease Systems



A fractional-horsepower hot-air solar engine at the National Physical Laboratory near Delhi, India

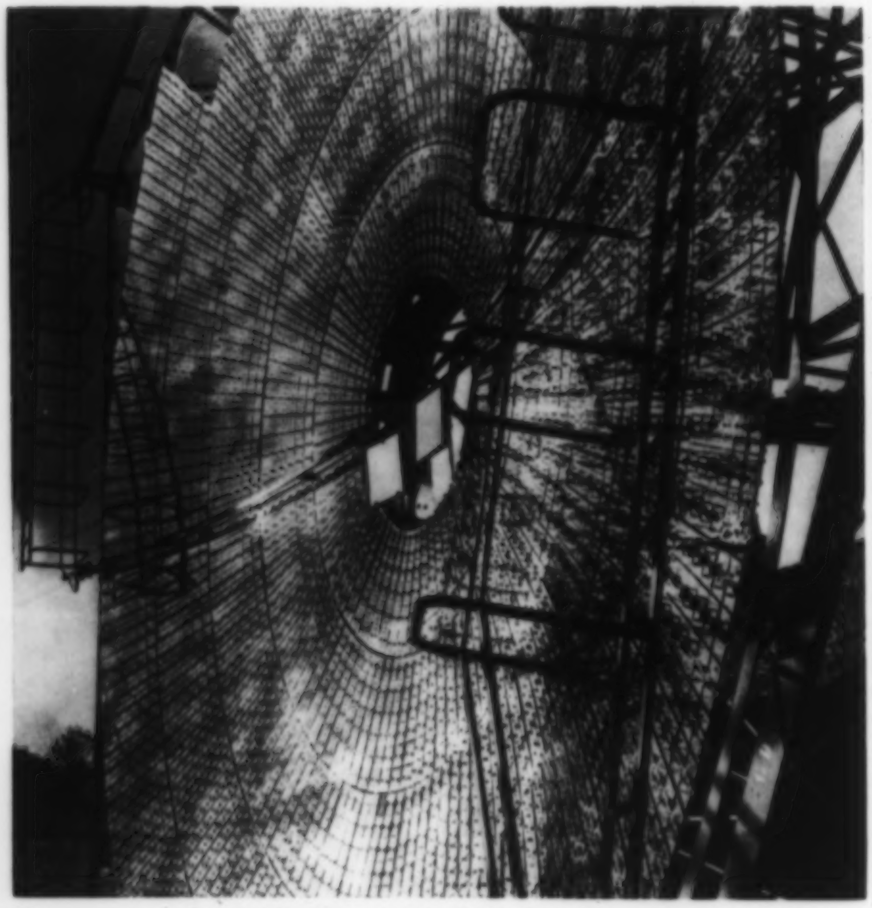
of flat mirrors or a single parabolic mirror are employed to concentrate light at one point.

Three mirror type units are in operation at the Convair Div. of General Dynamics Corp. Converted from searchlights, the furnaces are being used for high-temperature testing of metals, plastics, ceramics and other materials used in aircraft and missiles. Temperatures of over 7000 F are said possible. Convair has also had a 120-inch solar furnace in operation that is equipped with a device to control the amount of heat. It has an automatic tracking mechanism to keep it aimed at the sun.

A 40-foot mirror in the Pyrenees in France is used to produce refractory ceramics such as fused quartz and titanium dioxide on a commercial basis. Temperatures above 3000 C have been reached. it is reported.

Production of fertilizer by fixation of nitrogen in the atmosphere is being carried out by the use of a parabolic reflector furnace. In operation in Algiers, the furnace weighs 40 tons and is equipped with a 27½-foot diameter aluminum reflector.

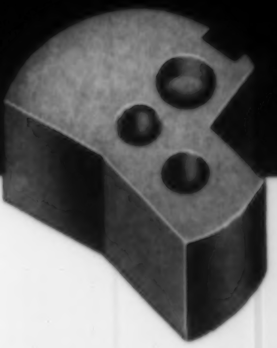
Many smaller mirror-type solar heaters have been designed for other uses. Solar stoves for cooking are being made for sale in fuel-scarce regions of the world.



Temperatures above 3000 C are attained in this 40-ft solar oven in France. It is being used commercially in the production of refractory materials

Rice cooker consists of 36 mirrors and is said capable of boiling water within an hour. The device is being demonstrated at the Goto Optical Laboratory in Japan

Other Types: Photoelectric power sources are being investigated as another method of utilizing



From the collection of Lewis Winant, New Jersey Arms Collectors Club. Maker: Wogdon, London, 1786-1787. An 11-by-14 inch print of this illustration will be sent free when requested on company letterhead.

challenge accepted

When this booster rotor, an artillery fuse component, was offered for production to the powder-metallurgy industry, Bound Brook was among those who were quick to accept the challenge. Initially, the part had been produced by machining brass bar stock, a method which proved to be both excessively costly and discouragingly slow. Powder metallurgy fabrication looked simple enough at first, until the critical weight and dimension factors were examined more closely—for in artillery fusing the difference between a hit and a dud can depend on a thousandth of an inch. By mustering all of its know how, accumulated in more than 30 years of producing metal-powder parts, Bound Brook emerged as the major producer of this rotor—at a cost nearly 40% less than was required for conventional machining.

10

BOUND BROOK

BOUND BROOK OIL-LESS BEARING CO. EST. 1883. BOUND BROOK, N. J.

Pioneer in

POWDER METALLURGY BEARINGS + PARTS

light energy. A silicon cell recently demonstrated by Bell Telephone Laboratories is said to have an efficiency of 8 per cent. Efficiency of a photoelectric exposure meter, for comparison, is only 1/10 of 1 per cent. With further development, the silicon cell efficiency may be increased to nearly 15 per cent. Investigations are being conducted currently to find other methods of recovering energy directly as electricity without going through moving machinery.

This 40-ton solar furnace is equipped with a $27\frac{1}{2}$-foot diameter parabolic reflector. In operation in Algiers, the furnace synthesizes nitric acid from air, water, chalk and sunshine

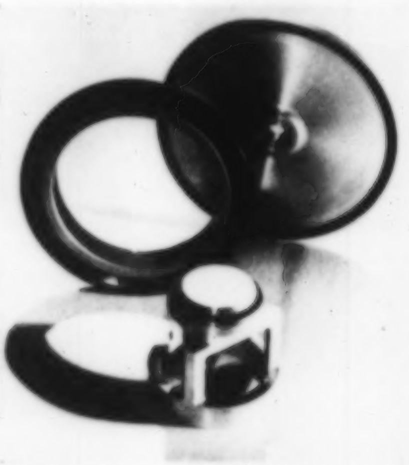
New Process Improves Rubber-to-Metal Bonding

Higher Accuracy, Finer Finish Claimed for New Method

Rubber-to-metal bonding of precision accuracy is now said possible by means of a new process called Permadizing. Developed by the Stillman Rubber Co., the technique is said to provide parts which are precise, free of flash and flaring of rubber and bonding agent on metal inserts.

It is reported that Permadizing makes available a rubber-to-metal material in which dimensional tolerances can be held as closely as on metal parts and which gives consistent, variation-free results even over long runs. The technique has successfully bonded aluminum to compounds of rubber, synthetic rubber or silicone.

Parts have been found to exhibit extremely low swell, are resistant to aromatic fuels and hydraulic fluids if properly compounded. They can be made corrosion-resistant and may be used under a wider range of temperature and pressure than previously possible.

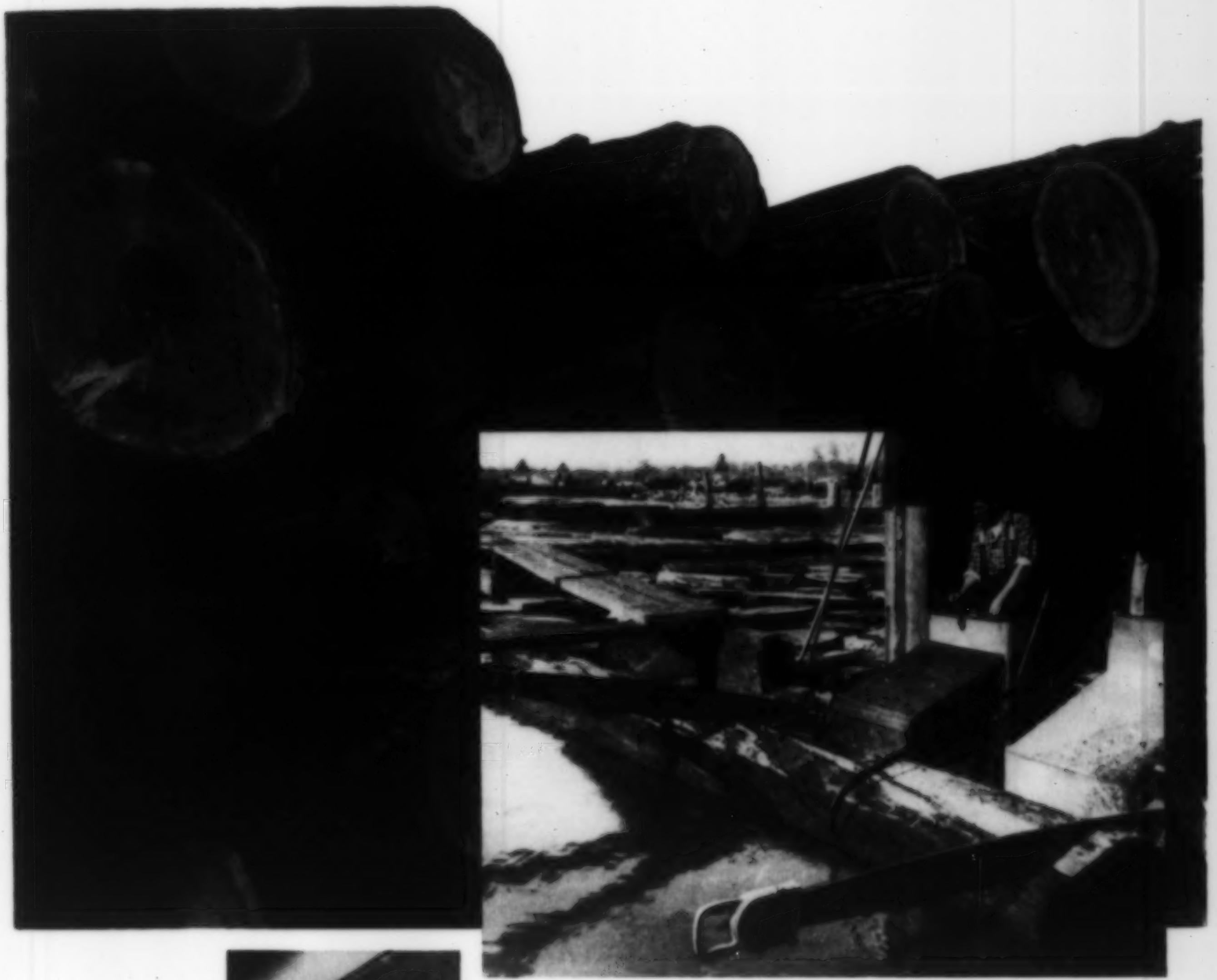


Three examples of Permadized rubber-to-metal bonded parts which may be used under a wide range of temperature and pressure

It is anticipated that the new process will be of special interest to designers and manufacturers in the aircraft industry who are concerned with extreme operating ranges of temperatures and pressures required by high-speed, high-flying aircraft. It is also expected to have many industrial applications where accurate and precise rubber-to-metal bonding is important.

Special reports on titanium compiled by the Office of Technical Services of the Department of Commerce are now available to private industry. Copies are in the reference libraries of the Cleveland and Cincinnati offices of the Department. Individual copies of the reports on titanium machining, fabrication and handling may also be obtained at varying prices, or the entire kit may be purchased for $40.00. Direct and sponsored research activities of the government are the source of these reports.

AGMA Index shows volume for the gearing industry to be increased by 4.1 per cent in April 1955, as compared with March 1955. The index figure for April 1955 is computed to be 179.8. AGMA index figures are computed using the 1947 to 1949 period as a base of 100.



L-M pond-type chain saws "bucking" log for a veneer plant.

Close-up of MAX-EL alloy steel chain saw bar, showing depth of heat treatment for tougher, longer-lasting bars.

it takes MAX-EL Alloy Steel to take a beating like this

Ram the flying teeth of a chain saw against a heavy log – and watch the sawdust fly! But don't forget – backing up that speeding chain is a bar that has to absorb all the shock . . . yet keep the chain lined up accurately, dependably.

That's a big reason why leading chain saw manufacturers, like L-M Equipment Company, Portland, Oregon, specify Crucible MAX-EL® alloy steel for chain saw bars.

And there are other reasons, too. For MAX-EL is not only tough, wear-resistant and dependable . . . but it also shows outstanding response to heat treatment . . . excellent machinability . . . high uniformity . . . minimum distortion. It's these qualities that permit L-M to machine their saw bars first – *then* give them a graduated heat treatment that insures toughness at the edges . . . flexibility in the main section.

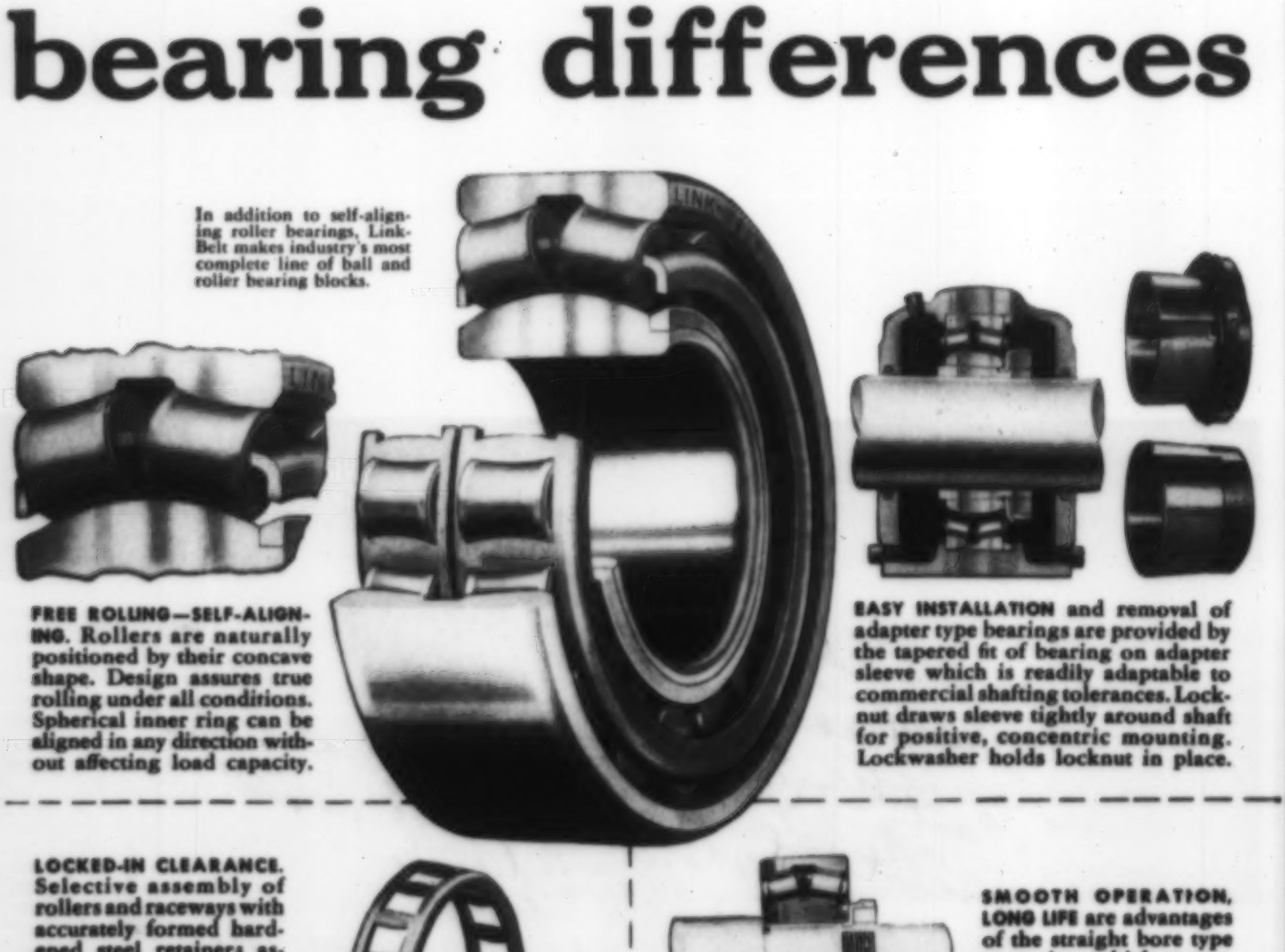
If your product requires a tough, machinable, non-deforming alloy steel – MAX-EL is for you. Try it. To see what information is available on MAX-EL – or *any* Crucible special steel – get your copy of the "Crucible Publication Catalog." Write *Crucible Steel Company of America, Henry W. Oliver Building, Pittsburgh 22, Pa.*

CRUCIBLE **first name in special purpose steels**

Crucible Steel Company of America

For tough, heavy-duty applications... Make use of these important

bearing differences



In addition to self-aligning roller bearings, Link-Belt makes industry's most complete line of ball and roller bearing blocks.

FREE ROLLING—SELF-ALIGNING. Rollers are naturally positioned by their concave shape. Design assures true rolling under all conditions. Spherical inner ring can be aligned in any direction without affecting load capacity.

EASY INSTALLATION and removal of adapter type bearings are provided by the tapered fit of bearing on adapter sleeve which is readily adaptable to commercial shafting tolerances. Locknut draws sleeve tightly around shaft for positive, concentric mounting. Lockwasher holds locknut in place.

LOCKED-IN CLEARANCE. Selective assembly of rollers and raceways with accurately formed hardened steel retainers assures proper operating clearance, guidance and spacing of rollers.

Rollers are completely pocketed in retainers for accurate spacing and guiding.

SMOOTH OPERATION, LONG LIFE are advantages of the straight bore type mounting, which assures maximum concentricity of inner ring with shaft. Especially desirable when minimum radial run-out is essential.

They're all present only in LINK-BELT self-aligning roller bearings

SUBTLE differences in bearings can make notable differences in the life and efficiency of your equipment. Take Link-Belt self-aligning roller bearings, for example. Their "self-contained" feature permits the bearing to float axially in the mounting, when desired, compensating for shaft expansion or settling of bearing supports . . . preventing extraneous thrust loads from being set up between bearings on the same shaft. What's more, inherent self-aligning design and preadjustment preclude use of expensive or cumbersome self-aligning housings.

Ask your nearest Link-Belt office for Book 2196 on self-aligning roller bearings and Book 2550, containing full data on all Link-Belt ball and roller bearings.

LINK-BELT

Ball and Roller Bearings

LINK-BELT COMPANY: Executive Offices, 307 N. Michigan Ave., Chicago 1. To Serve Industry There Are Link-Belt Plants, Sales Offices, Stock Carrying Factory Branch Stores and Distributors in All Principal Cities. Export Office, New York 7; Canada, Scarboro (Toronto 13); Australia, Marrickville, N.S.W.; South Africa, Springs. Representatives Throughout the World. 13,711

Giant Press Begins Operation

Heavy Press Becomes Latest Air Force Addition

A new 50,000-ton hydraulic press, designed and built by the Mesta Machine Co. for Alcoa, was recently put into operation. It is said to rank among the world's largest metalworking machines.

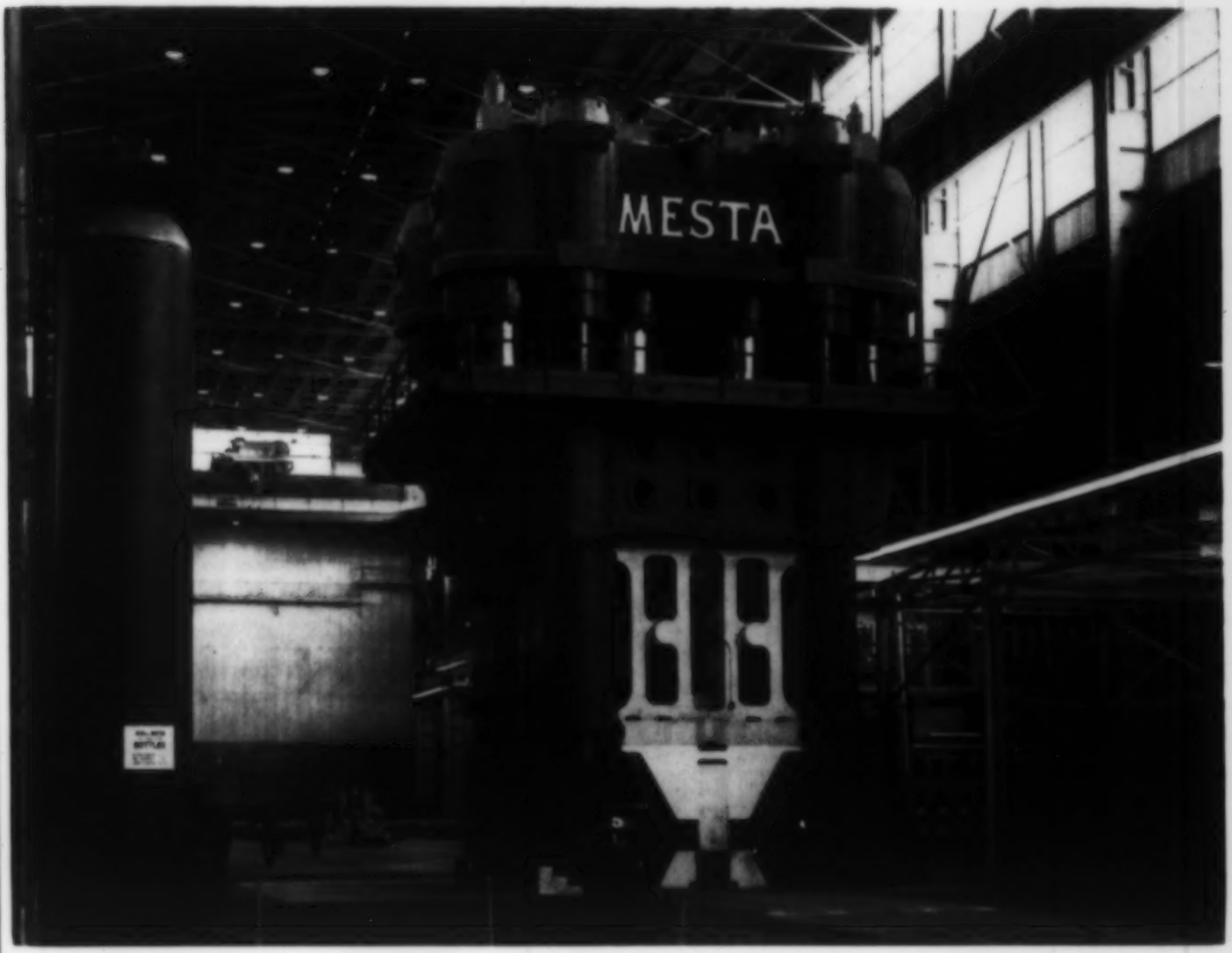
The press is 87 ft high, extending 51 ft above ground level and 36 ft below. Running through it from top to bottom are eight alloy-steel columns, each 76 ft long and 40 inches in diameter. Total weight of the press is approximately 8000 tons. The die table, 12 ft wide by 26 ft long, is withdrawn only when the forging dies are changed. Forged parts are removed and ingots inserted between the dies by a manipulator. Maximum press stroke is 6 ft, with a working stroke of 1 ft designed to operate at 30 cycles per hr.

Press force is generated by the hydropneumatic pressure system consisting of four prefiller bottles, two horizontal reciprocating pumps driven by 1500-hp motors, and four pressure-accumulator bottles. Hydraulic fluid is water containing a small percentage of soluble oil to lubricate the system and prevent corrosion. Pressure of 4500 psi is built up in each accumulator and released to eight pressure cylinders housed in the stationary crossheads at the top of the press. Combined effort of the cylinders produces the 50,000-ton forging capacity.

Dies are preheated before forging in a specially constructed battery of furnaces near the press. Lubricant is sprayed on the dies.

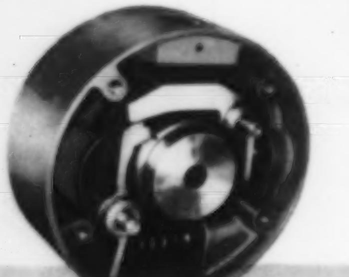
Heavy precision forgings produced on the press are said to make possible stronger, lighter and less-expensive components for aircraft. Size of the forgings will permit one-piece construction of airframe parts formerly requiring several pieces. Built for use in forming aluminum and magnesi-

(Continued on Page 24)



Ground-level view of the 50,000 ton press. At the top of the press are the stationary crossheads which house the eight pressure cylinders. Pressure of 4500 psi is built up in each accumulator and fed to the pressure cylinders. One of the four accumulator bottles can be seen at the left

AT LAST!

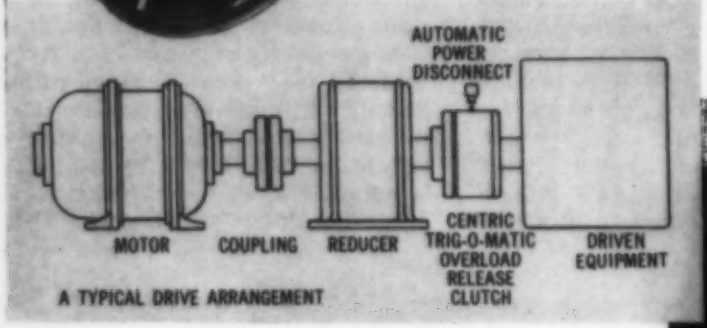


One of the greatest advancements against overloads in power drives

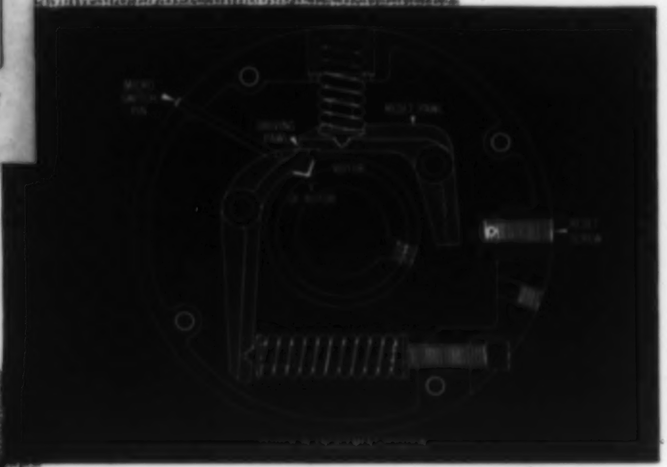
the New-Field Tested-Long Life CENTRIC

TRIG-O-MATIC OVERLOAD RELEASE CLUTCH

—provides positive torque limit without any wearing parts accomplished by the lock-out design which provides complete disengagement.


AUTOMATIC POWER DISCONNECT
MOTOR
COUPLING
REDUCER
CENTRIC TRIG-O-MATIC OVERLOAD RELEASE CLUTCH
DRIVEN EQUIPMENT

A TYPICAL DRIVE ARRANGEMENT



How the Trig-O-Matic works:

In engaged position — Clutch is preset to a definite torque limit by the two coil springs, which are fully adjustable to any required torque range accommodated in the basic 8 units available. The driving pawl, in this position, is locked into the "V" of the rotor. This with reset pawl gives the total torque limit setting.

Disengaged through overloads. Driving pawl is locked out from the "V" of the rotor by the reset pawl. Action of micro-pin on micro-switch shuts down power supply or provides a signal.

Simplified re-engagement. Easy adjustment of reset screw brings unit to exact position of original engagement.

There's a "CENTRIC" for every type drive

Type A Clutch Couplings for Motor Drives
Type A Spring Control Clutch Couplings for Engines and Dual Drives

All in ranges from fractional and unit h.p. to heavy industrial 2500 h.p.—and in the TYPE AVL Industrial Vertical Lift-out.

Type B Indirect Drive Clutches

Six basic models to fit standard pulleys, "V" belt sheaves and sprockets for motors, engines, and dual drives.

What is your drive problem? May we help solve it?

CENTRIC *Clutch Company*

P. O. BOX 175 • U. S. ROUTE 9 AT MAIN STREET • WOODBRIDGE, NEW JERSEY

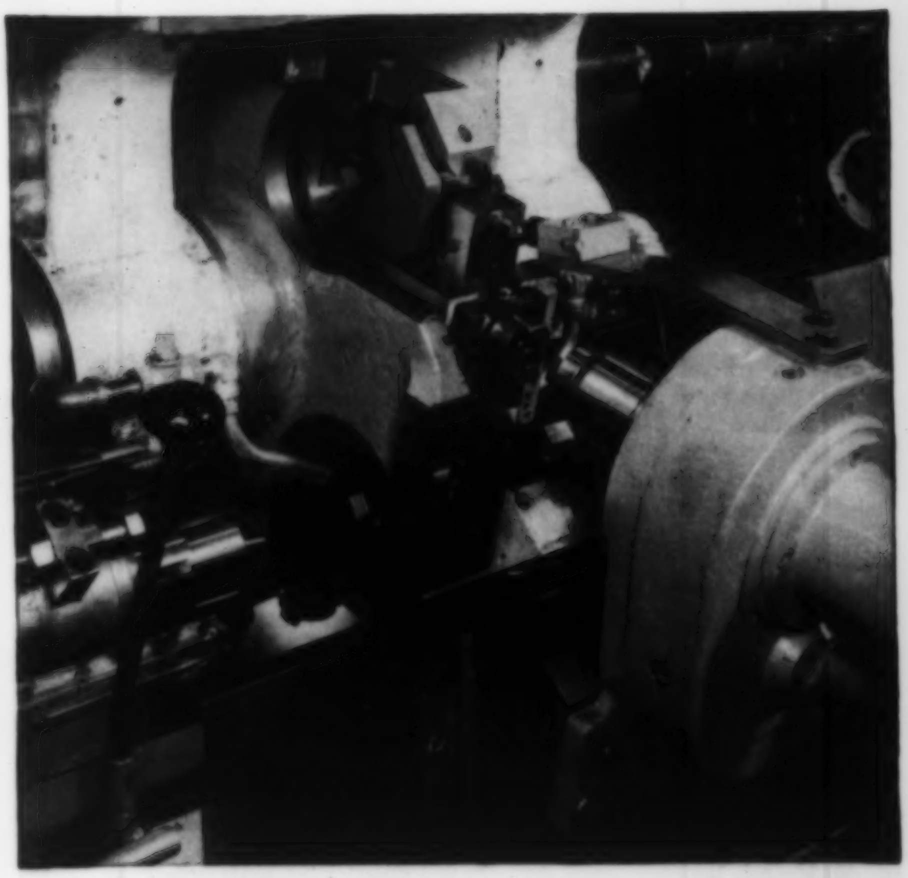
More precision—no more backlash after turret was mounted on TIMKEN® bearings

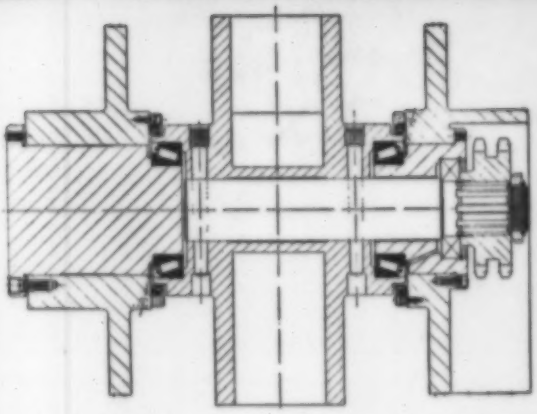
50 Timken® bearings are used in this Model 365 New Britain chucking machine, which can machine both ends of suitable castings or forgings simultaneously. The turret spindle of this machine was originally mounted on a plain bushing. This method did not eliminate backlash completely. When Timken tapered roller bearings were mounted at each end of the turret shaft, backlash was eliminated altogether, rejects cut. Timken bearings also prevent chatter and insure precision because they can be preloaded to any degree necessary to maintain the required rigidity.

Timken bearings can handle heavy loads because they carry them on the lines of contact between rollers and races. Their tapered construction permits them to take radial and thrust loads in any combination. Geometrically designed for true rolling motion and precision manufactured to live up to their design, Timken bearings practically eliminate friction.

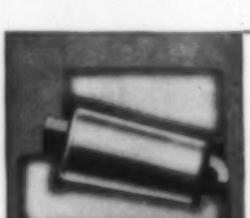
We even make our own special analysis nickel-rich steel to be sure Timken bearings are the best. We're the only U. S. bearing maker that does. When you buy or build machines, always specify Timken bearings. Look for the trade-mark "Timken" on every bearing. The Timken Roller Bearing Company, Canton 6, Ohio. Canadian plant: St. Thomas, Ontario. Cable address: "TIMROSCO".

This symbol on a product means its bearings are the best.





How **THE NEW BRITAIN MACHINE COMPANY** mounts the turret of its Model 365 Double-End Automatic Chucking Machine on Timken bearings to improve precision, minimize maintenance.



GREATER LOAD AREA

Because the load is carried on the *line* of contact between rollers and races, Timken bearings carry greater loads, hold shafts in line, wear longer. The Timken Roller Bearing Company is the acknowledged leader in: 1. advanced design; 2. precision manufacturing; 3. rigid quality control; 4. special analysis Timken steels.

TIMKEN

TRADE-MARK REG. U. S. PAT. OFF.

TAPERED ROLLER BEARINGS

NOT JUST A BALL ○ NOT JUST A ROLLER ▭ THE TIMKEN TAPERED ROLLER ▭ BEARING TAKES RADIAL ↕ AND THRUST ↔ LOADS OR ANY COMBINATION ✳

(Continued from Page 21)

um, it is believed that the press may be practical also for forming other metals.

SMALLEST RELAY of its rating ever developed, according to General Electric, is less than 1 inch high and weighs 10 grams. Its contact rating is 2 amp at 30 volts dc or 115 volts ac. Hermetically sealed, the relay is rated for operation at 1.5 milliseconds

Cameraless Television Uses Flying Light Spot

Modern Components Refine Old Scanning System

Refinements on the old flying-spot television scanning system have resulted in acceptable color television pictures without using a camera, according to a recent report. Light from a cathode ray tube is focused to a narrow beam. By applying proper sweep frequencies to the tube, the spot systematically scans an entire room. Banks of photocells placed around the studio pick up the reflected light from the objects in the room. Appropriate circuits convert the photocell output into video signals.

Developed by Allan B. Dumont Laboratories Inc., the principle is based upon one of the first television principles—flying spot scanning. Instead of the old rotating disk to direct the beam over the area being scanned, a cathode-ray tube and lens system has been designed to do the job. No moving parts are required. Multiplier phototubes replace the older, relatively insensitive photocells originally used for pickup.

Among the advantages claimed for the system are: (1) elimination of TV cameras—color or black and white, (2) no color registration problems, and (3 practically no warmup time required.

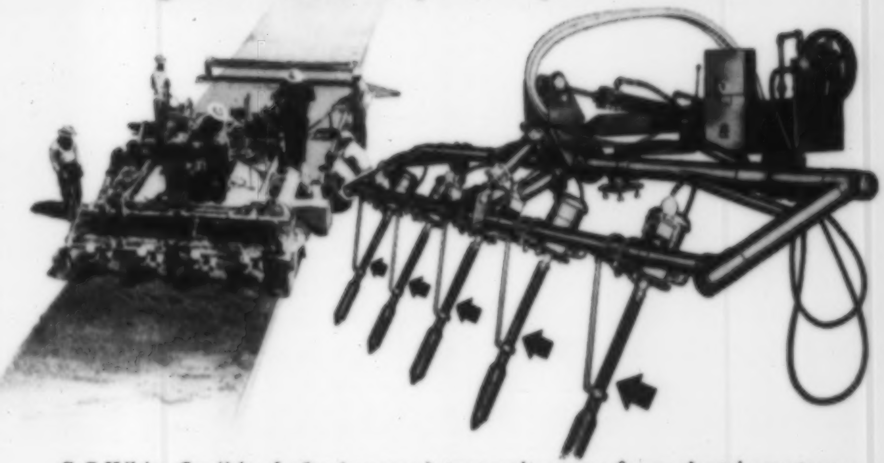
A unique by-product of the system is a synchronized light source to provide general studio illumination. Stroboscopic lamps are timed to flash on during the blanking intervals in scanning. These pulses occur at 60 cps. As a result, the studio is fully lighted at all times, but the light does not interfere with the scanning.

AWARD PRESENTATION: Colin Carmichael, editor of *Machine Design*, left, receiving a first-award plaque for the best single issue of 1954 in the 17th Annual Business Paper Editorial Achievement Competition. G. D. Crain Jr., publisher of *Industrial Marketing*, is presenting the award. Best single issue was the engineering materials special issue of May, 1954

Carborundum Co., Niagara Falls, N. Y., has purchased the Curtis Machine Corp., according to a joint announcement by Gen. Clinton F. Robinson, president of Carborundum and Mr. Gene DeMambro, president of Lincoln Park Industries Inc., of which Curtis Machine was a wholly owned subsidiary. Mr. DeMambro, president

S.S.White
Flexible Shafts
meet the toughest
performance
standards

In rugged construction equipment,
S.S.WHITE FLEXIBLE SHAFTS
give reliable, day-in, day-out service



S.S.White flexible shafts (arrows) transmit power from electric motors to the vibrating heads of this multiple concrete vibrator. Used to compact stiff concrete mixes in highway and airport runway construction, this machine puts a premium on performance — a test which S.S.White flexible shafts pass with flying colors. Where dependability counts, you can always rely on an S.S.White flexible shaft because it's performance-proved for any application, large or small.

If you have a problem involving the transmission of rotary power or remote control it will pay you to contact S.S.White FIRST. Engineering cooperation is always available. There's no obligation.

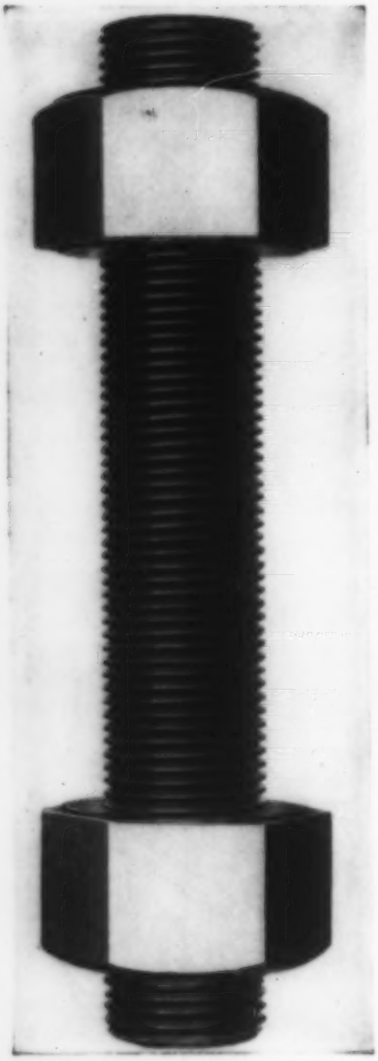
S.S.White
FLEXIBLE SHAFTS

Flexible shaft information for you...
Bulletin 5306 has basic information and data on flexible shaft selection and application. Send for a copy. Address Dept. 4.

S.S.WHITE INDUSTRIAL DIVISION 10 East 40th Street, New York 16, N. Y.

S.S.White FIRST NAME IN FLEXIBLE SHAFTS

F-6



WHEN IT'S
Special BOLTS
and STUDS

Send your Specifications to

ERIE

40 years' experience in making special bolts, studs, nuts for specific job requirements.

16
INTEGRATED COMPANIES
BARIUM
STEEL CORPORATION
WORKING IN
STEEL, ALUMINUM
MAGNESIUM, FIBERGLASS

REPRESENTATION IN PRINCIPAL CITIES

and general manager of Curtis Machine, will continue in that capacity.

New engine plant with capacity for building V-8 engines for Plymouth cars at three times the current volume will be in operation in Detroit by the late fall of 1955, J. P. Mansfield, Plymouth president, announced recently.

Motorola Inc. has begun construction of a $1½ million transistor manufacturing facility in Phoenix, Arizona. The entire building and its equipment will be devoted to the research, development and production of transistors and other semiconductor devices.

Screws Untouched By Human Hands

Automatic Screwdriver Feed Cuts Time, Handling

Screws are fed automatically to a power driver with a new system designed to save assembly time and reduce material handling. Designed by Taymouth Industries Ltd. of Toronto, the device is being assembled in this country by Pneuma-Serve Inc. of Cleveland.

All standard types of screws up to ¼-inch in diameter can be handled by the machine. Lengths up to 1¼ inch can be accommodated, according to the company. Any type head style, including wood screws, self-tapping screws and machine screws can be handled. Screws with the washer attached are said easily fed.

A hopper capable of holding from 5 to 8 hours' work is connected to a special driver head by plastic tubing. Screws pass through the tubing, one at a time, to the head where they are held in position for driving. Because the screws themselves act as a finder or drift, no manual handling is necessary. Up to 20 feet of tubing may be used to connect the head to the hopper. The special head is made to be adaptable to existing driving tools.

Operator fatigue due to manual

PREVENT
STICKING
of VALVES

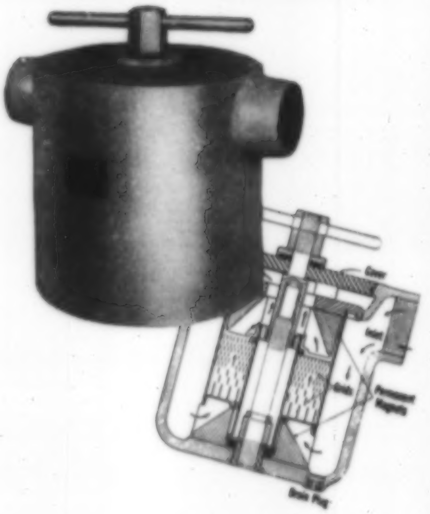
.....and
other precision
working parts

by removing ferrous grit
from fluid power systems

USE...

FERROFILTER

Magnetic Separators



Keep your oil free of iron contamination—minute particles that can jam in close clearances of working parts. Frantz FERROFILTERS not only extract ferrous particles that make valves stick but take out metallic abrasives which wear and score precisely fitted components causing leakage, misfunction and downtime. For complete information on the application and operation of FERROFILTERS . . .

SEND FOR BULLETIN PM-83

S. G. FRANTZ CO., INC.
Brunswick Pike & Kline Ave.
P. O. Box 1138 Trenton 6, N. J.

placing of screws is said eliminated. Also, there is little possibility of screws being wasted by dropping on the floor. In recent tests, an operation requiring placement of 17 screws in an irregularly shaped pattern was said to require only a little more than 17 seconds.

• • • ALCOHOL FREEZER *in a handy kit form has been developed by Armour Research Foundation to accurately determine the freezing point of various antifreeze solutions. Liquid carbon dioxide is injected into the solution until it turns into slush. The point at which the slush begins to melt is the freezing point. Freezing the drinkable variety of alcohol into ice cubes might solve that ever present problem of highball dilution.*

Glass Pods Hold Electric Generators

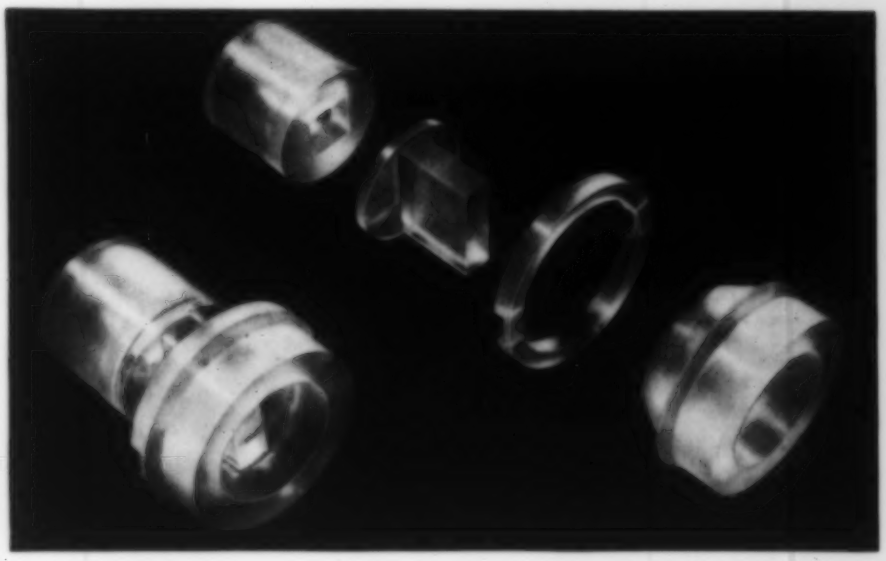
Aircraft Units Mounted at Wingtips

Manufacture of pod-mounted gas-turbine electric generators for Convair C-131B flying electronic laboratories has been announced by Solar Aircraft Co. Two of the power units will be installed on each plane, hung from the wings in glass-fiber pods. This is the first such installation for airborne gas-turbine generators.

Either direct or alternating current, or a combination of both, can be supplied. As much as 30 kw of direct current or 40 kva of alternating current can be supplied at an altitude of 25,000 ft.

These gas turbine units are smaller than a 2-ft cube, are powered by a 50 hp engine that weighs 100 lb and operate at a speed of 40,000 rpm.

American Institute of Electrical Engineers has elected Morris D. Hoven as president for 1955-56. Mr. Hoven is an electrical engineer in the electrical engineering department, Public Service Electric and Gas Co., Newark, N. J.



prove it works **before** you go into production

Machine that part from polystyrene and let us investment-cast it in the metal you plan to use. Test it and, if some change is indicated, repeat the process until you have the final answer. This cut-and-try method of proving a design and an alloy saves you a lot of time and money.

Polystyrene machines readily and is inexpensive. Complex patterns can be made in sections and assembled, then cast as a unit just as they'd be investment-cast in quantity. Thus parts for testing are exactly like you'll get in production, but they cost far less than cutting them out of metal.

Technical Data Available

When your idea is on paper, but before you start to make the polystyrene patterns, send us a blueprint. We'll figure the shrinkage factor for you, suggest possible gating arrangements and design modifications which may effect further economies.

The pamphlet, *A Guide for Making Polystyrene Patterns*, describes methods of machining and names sources from which this material can be obtained. For a free copy, write Precision Metalsmiths, Inc., 1083 East 200th Street, Cleveland 17, Ohio.

pour yourself an assembly with

PRECISION METALSMITHS, Inc.

Investment Castings

"THIS LUBRICANT INCREASED BEARING LIFE FROM 2 WEEKS TO 2 YEARS"

—says THE GLOBE COMPANY

"Animal acids and moisture, most harmful to ball and roller bearings prevails in the entire meat packing industry. With conventional lubricants, some of the bearings in our Roto-Cut machines did not last two weeks. Since using Ball Bearing LUBRIPLATE in machines operating continuously 24 hours a day for over two years, we have not had a single bearing replacement."

REGARDLESS OF THE SIZE AND TYPE OF YOUR MACHINERY, LUBRIPLATE GREASE AND FLUID TYPE LUBRICANTS WILL IMPROVE ITS OPERATION AND REDUCE MAINTENANCE COSTS.

LUBRIPLATE is available in grease and fluid densities for every purpose... LUBRIPLATE H. D. S. MOTOR OIL meets today's exacting requirements for gasoline and diesel engines.

For nearest LUBRIPLATE distributor see Classified Telephone Directory. Send for free "LUBRIPLATE DATA BOOK"... a valuable treatise on lubrication. Write LUBRIPLATE DIVISION, Fiske Brothers Refining Co., Newark 5, N. J. or Toledo 5, Ohio.

THE MODERN LUBRICANT
"It's the Film"
PREVENTS WEAR AND CORROSION
LUBRIPLATE
SUPER LUBRICATION
FISKE BROTHERS REFINING CO.

Preheated Electrode Speeds Welding Rate

New Process Increases Metal Deposition to 100 lb per hr

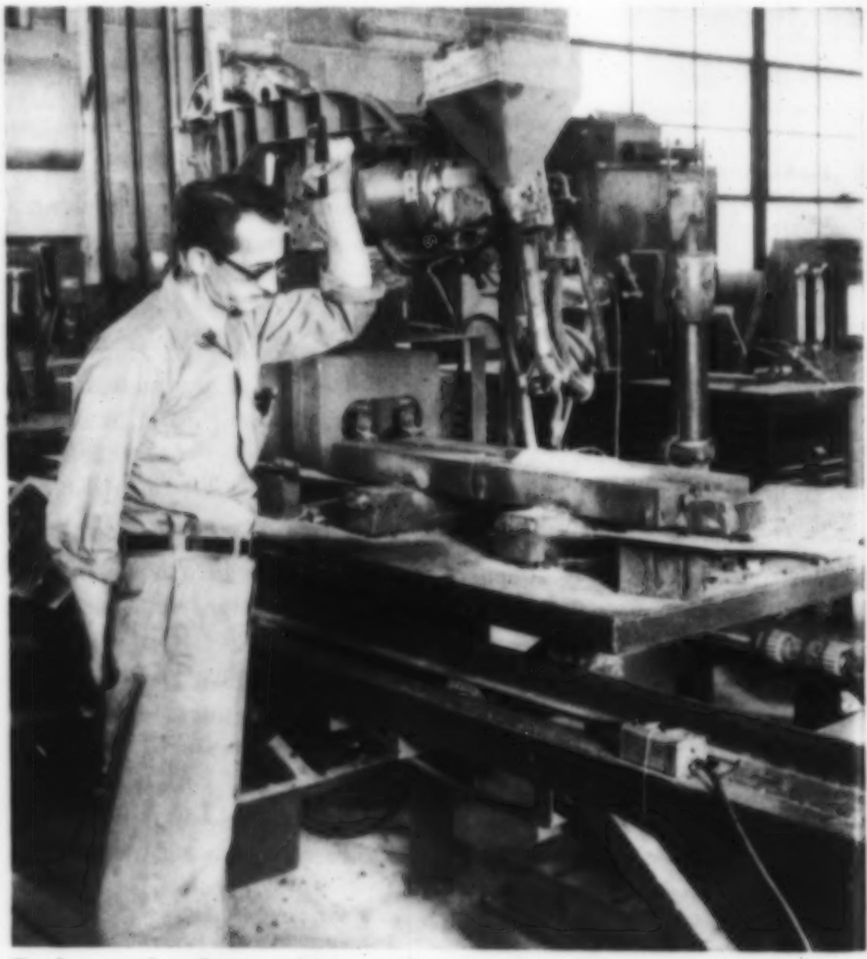
Preheating the welding electrode before it enters the arc has been found to increase metal deposition rate in a new welding technique. Because the electrode is heated almost to its melting point, the arc does not have to supply the heat necessary to bring the metal to the melting point. As a result, nearly all the energy absorbed by the electrode at the arc supplies heat of fusion to melt the metal.

Current densities used in the new technique vary from 70,000 to 270,000 amp per sq in. These ranges are possible only with submerged-arc or inert-gas welding. Flux-coated electrodes would be damaged by these high currents.

According to Babcock & Wilcox, developers of the high-speed technique, metal deposition rates of 100 lb per hr are now common. Standard submerged-arc welding processes are said to deposit about 30 lb per hr. Investigations are being conducted on a method to deposit 200-250 lb per hr using a current of 1800-2000 amp.

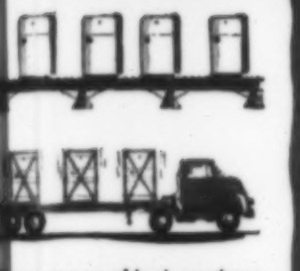
Granular flux, through which the bare electrode is fed, is composed of finely divided metal oxides. Babcock & Wilcox is currently using carbon-steel wire electrodes with tensile strengths up to 70,000 psi.

One of the advantages claimed for the new process is the small amount of base metal melted. About twice as much filler as base metal is melted, according to the company.

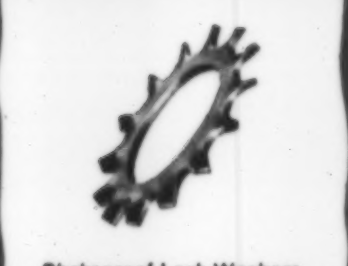


Equipment for the new high-speed automatic welding process includes an electrode preheater and a specially designed guide

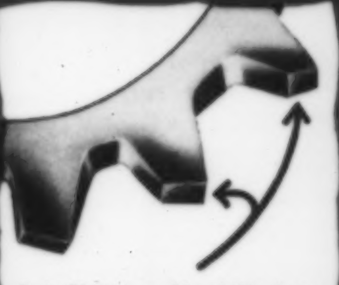
Why
SHAKEPROOF® LOCK WASHERS
defeat vibration!



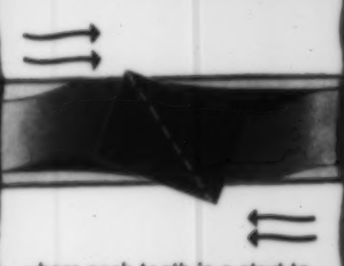
e purpose of lock washers is to keep screws and nuts tight.



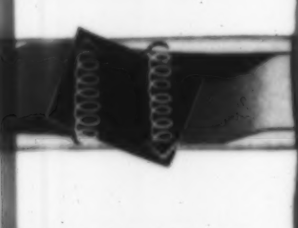
Shakeproof Lock Washers provide positive locking action that ordinary washers cannot give.



Only Shakeproof Lock Washers have these exclusive tapered-twisted teeth ...

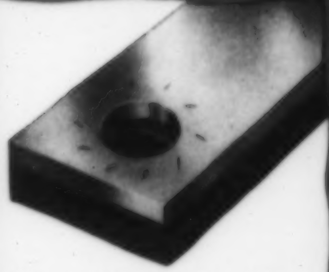


where each tooth is a strut to resist all loosening rotation of threaded fastening.

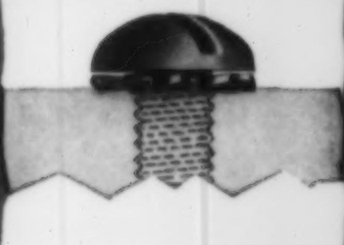


pring tension forces the edges of each tooth to bite deeper.

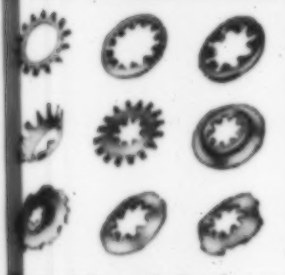
Shakeproof Lock Washers lock tighter as vibration increases ...



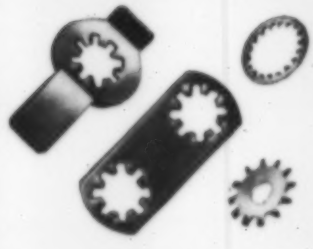
and the locking power of each tooth is multiplied by the number of teeth.



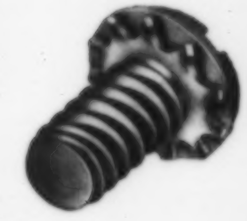
Their exclusive mechanical lock resists loosening as no other lock washer can!



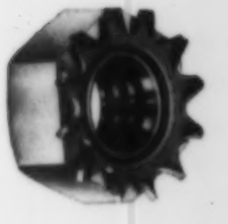
meet the majority of your locking needs, there are nine standard types.



The variety and styles of "specials" to meet individual requirements are unlimited!



For maximum savings, buy Shakeproof Lock Washers pre-assembled on screws as SEMS.



Pre-assembled on nuts, Shakeproof Lock Washers save time—specify KEPS®.

Free Sample Kit

... make your own tests! See for yourself how SHAKEPROOF ock Washers can save time in assembly and protect the quality of your products. Write for your free sample kit today!

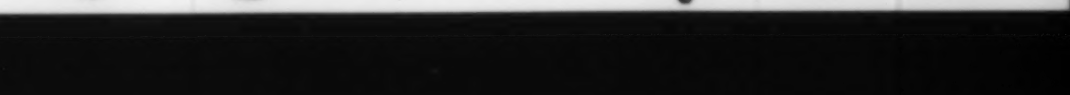
SHAKEPROOF

"Fastening Headquarters"®

DIVISION OF ILLINOIS TOOL WORKS

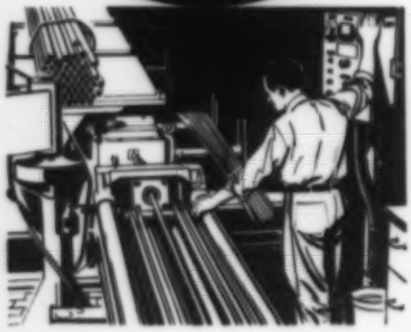
St. Charles Rd., Elgin, Illinois • Offices in Principal Cities
In Canada: Canada Illinois Tools Limited, Toronto, Ontario

RLD'S BROADEST LINE OF
S-ASSEMBLY FASTENINGS



Quality BY DESIGN

WALLINGFORD WELDED STAINLESS TUBING AND PIPE



WALLINGFORD has the right combination for producing Welded Stainless Tubes and Pipe of the highest quality . . . skilled personnel, modern equipment, and exacting methods of manufacture and control.

At WALLINGFORD, everything that **can** be done to assure quality *is* done. That's why Wallingford stainless tubing is cold drawn to obtain the correct OD, ID and wall thickness . . . with closer tolerances and better physical properties. The result is tubing that will meet your requirements for uniformity, heat and corrosion resistance, longer tool and die life.

FREE TUBING BOOKLET WRITE FOR YOUR COPY

. . . and get complete details and ordering information on Wallingford quality tubing and pipe.

THE WALLINGFORD

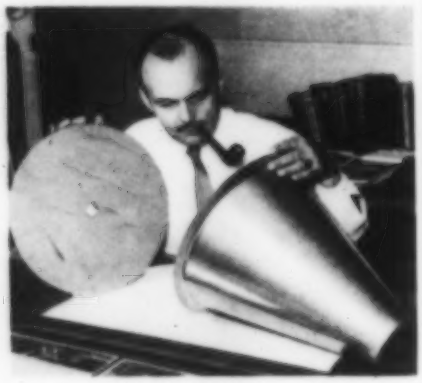
SINCE 1922

STEEL CO.

WALLINGFORD, CONN. U.S.A.

STAINLESS • ALLOY • HIGH CARBON
LOW CARBON • STRIP and TUBING

The new process has been applied to automatic techniques by designing a special guiding device that keeps the weld head and arc true to the work. It is claimed that beads are deposited too fast for manual handling. A voltage-sensitive relay controls the length of the electrode projecting from the nozzle. Changes in load voltage actuate the relay which, in turn, controls the raising and lowering of the weld head.



BEFORE AND AFTER: Alloy steel disk on the left was spun into the cone-shaped piece on the right on a Hydrospin machine. Made by Cincinnati Milling Machine Co., the machine uses hydraulically - controlled rollers to cold-flow the material onto a rotating mandrel. Being used by Solar Aircraft Co., the machine is said to have successfully formed inch-thick mild steels

Borg-Warner Corp., through its Long Mfg. Div., will build and market a line of industrial torque converters, according to an announcement by T. J. Ault, Long Manufacturing's president and general manager.

Federal Machine & Tool Co. Inc., has acquired Atlantic Carbide Co. and Colonial Tool & Cutter Co., both of Rochelle Park, N. J. The company will operate as Federal

ANGLgear Horsepower UP...

MODEL 340

MODEL 350

...but price stays down!

3 hp at 1200 rpm! That's the new rating of the rugged 2 and 3-way ANGLgear models shown above. And — we repeat — there is no change in purchase price.

The expanding ANGLgear line — now including 1/3, 1 and 3 hp units available with 1-1 or 2-1 gear ratio and with either 2 or 3-shaft extensions — enjoys wide acceptance in many fields. It's sold only through your local distributor. See our literature in the product design section of Sweet's Catalog.

AIRBORNE
ACCESSORIES CORPORATION
HILLSIDE 5, NEW JERSEY

Carbide & Cutter Co. Inc., and will be affiliated with Federal Machine & Tool Co. Inc. and the latter's subsidiary, Federal Services Co.

Starr-Kap Engineering Co., Detroit, manufacturers and designers of tools, dies, jigs, fixtures, gages and special machinery, has announced the completion of a new building.

Byron Jackson Co. has merged with Borg-Warner Corp. and will continue to operate as an independent operating unit with no change in management, personnel or policy.

Code Library Speeds Computations

Computer Instructions Kept For Engineering Problems

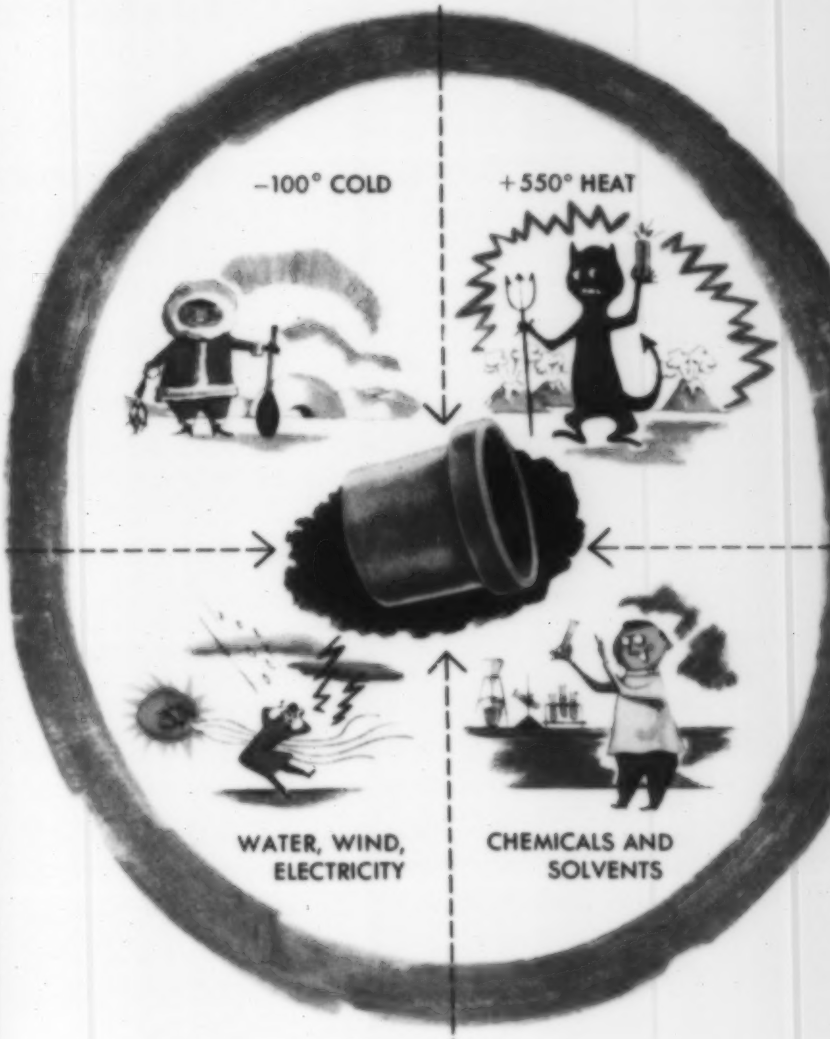
Development of a computer code library which speeds completion of engineering computations has been announced by Midwest Research Institute. Complex calculations may take minutes to perform on a computer. However the process of setting up the coding prior to operation of the calculator may take days, weeks or months. In such cases, lengthy, one-time computations are often not economically handled by a computer.

One solution to the high cost of coding has been to establish a library containing computer instructions for a wide variety of problems in chemical, civil, electrical and mechanical engineering. Once a code is prepared for a particular engineering problem, no further coding is required.

With this system, according to Dr. Sheldon Levy, manager, Applied Physics Div., the client need pay only for the actual time spent in calculation on the calculator, plus a nominal per cent which is credited to the development of the code library. New codes will be added to the library as each new problem is completed, according to Midwest.

(*Continued on Page* 36)

A typical day for a rubber part molded from SILICONE by ROTH



Do you have a rubber part problem that can't be solved due to temperature extremes, weathering, resistance to chemicals or poor dialectric properties? If so, ROTH Rubber may have the answer in molded *Silicone* parts. It costs only a phone call or letter to find out if ROTH can solve your problem. Why not let ROTH work on it for you? No obligation.

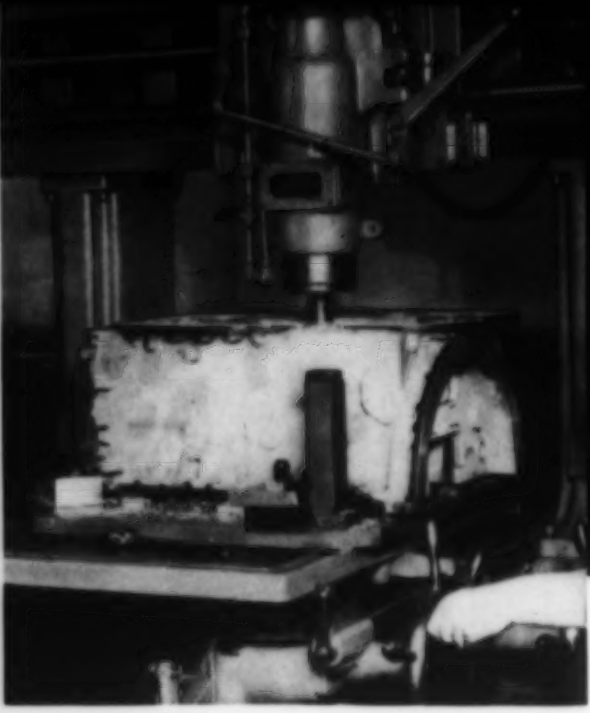
Engineers and Rubber Buyers!

Write for your free Roth Rubber Sampler. This unusual kit contains actual rubber samples with hardness from 5 to 100 Durometer...gives ASTM specs and lists uses for each sample. Sorry, but offer must be limited to engineers and rubber buyers only. Please ask for Roth Rubber Sampler No. MD7.

ROTH RUBBER COMPANY

1856 S. 54th Avenue, Chicago 50

Custom Manufacturers of Industrial Rubber Products Since 1923



If limits are measured in .0001ths

chances are

Fafnir has a bearing on it

Precision designing and construction of the spindle head illustrated make possible extremely accurate profiling or milling at twelve operating speeds ranging from 260 to 6200 rpm. Design specifications include four pairs of Fafnir Super Precision Ball Bearings on the spindle shaft. These "jewels of industry" provide the ultimate in axial and radial rigidity. They run cool under exacting conditions of load and speed . . . conserve power . . . need no adjustment . . . and are permanently grease-packed.

It's in places like this where limits are in .0001ths that you find Fafnir Super-Precision Bearings . . . because they are *manufactured* in a separate super-precision department to the highest standards of dimensional control . . . in a wide range of sizes and types. There could be no better example of the "attitude and aptitude" of Fafnir engineers toward solving bearing problems.

If bearings are important to you, a few minutes spent with a Fafnir representative may help you get the right answer quickly. The Fafnir Bearing Company, New Britain, Connecticut.

MOST COMPLETE LINE IN AMERICA

Fafnir Super-Precision, Duplex-Type Preloaded Ball Bearings of counterbore construction . . . one piece composition retainers.

FAFNIR BALL BEARINGS

When you design for SOCKET SCREWS

USE AN H-K *SELECTOR*

HK
HOLO-KROME
SELECTOR

. . . *you don't need anything else!*

Provides more pertinent data than you can find in a Catalog!

IT QUICKLY GIVES YOU:

DIAMETERS • PHYSICALS • TORQUE

STANDARD LENGTHS • STANDARD POINTS

ALL PERTINENT DIMENSIONAL AND PHYSICAL DATA

The H-K Selector is definitely not a "gadget". It was designed by design engineers *for* design engineers . . . and it gives the designer every bit of information he must have to select the proper size and type of Socket Screw. It's a complete working tool which we believe you will find very helpful in your work—***and it's free for the asking!***

HK
HOLO-KROME
SELECTOR

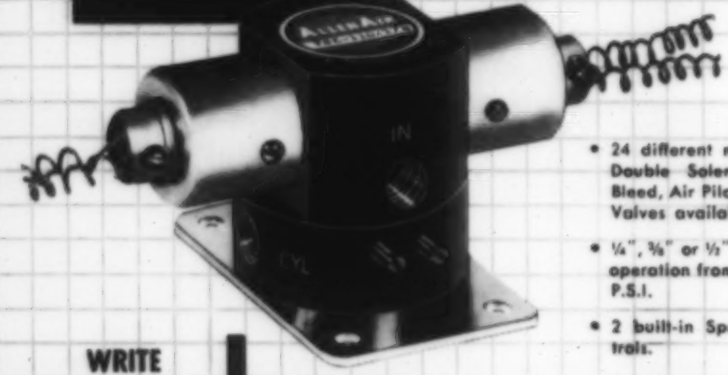
Another Holo-Krome service feature—along with SAME-DAY SERVICE on catalog items, SAME-DAY INQUIRY SERVICE, SPECIALS shipped in 4 weeks or sooner!

HOLO-KROME
Completely Cold Forged
SOCKET SCREWS

THE HOLO-KROME SCREW CORP.
20 BROOK ST., HARTFORD 10, CONN.

BRAND NEW!

ALLEN AIR
4-WAY
VALVES



- 24 different models of Double Solenoid, Air Bleed, Air Pilot & Hand Valves available.
- ¼", ⅜" or ½" Ports for operation from 5 to 150 P.S.I.
- 2 built-in Speed Controls.

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ALLEN AIR—manufacturers of Dial Feed Tables, Valves, Clamps & Cylinders (plain or with built-in valves. Up to 20" of stroke in stock.)

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Are parts machined for you under . . .

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QUALITY CONTROL?

NON-GRAN
PRECISION MACHINE WORK
CASTINGS • SAND & CENTRIFUGAL

At NON-GRAN they will be. We machine parts, in any metal, under industry's newest approach to better products, at lower cost. Isn't this the way you want parts machined for assembly in products you design? Others find it pays in easier, faster assembly — far greater production control. See what it can mean to you, write for folder—"Better Production Control."

AMERICAN NON-GRAN BRONZE COMPANY
Berwyn, Pa. . . . *Metropolitan Phila., on the Penna. R. R. main line.*

(Continued from Page 31)

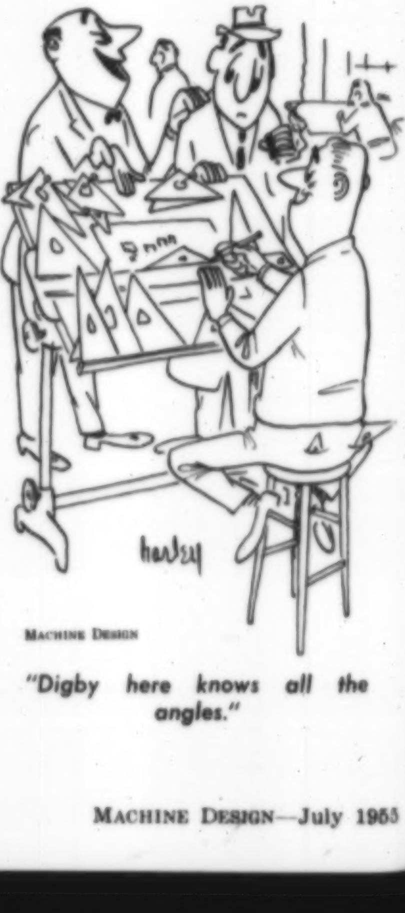
New Silicone Rubber Resists High Temperature

Application Range Extended to 600 F

A new type of silicone rubber, said to be capable of remaining flexible at 600 F, has been developed by General Electric's Silicone Products Department. Former silicone rubbers have been limited to a maximum usable range of about 500 F.

The new materials, designated Class 700, are reported to remain flexible for 150 hours or longer during continuous exposure up to the peak of the new temperature range. Previously available silicone rubber became brittle in less than 24 hours exposure to this heat.

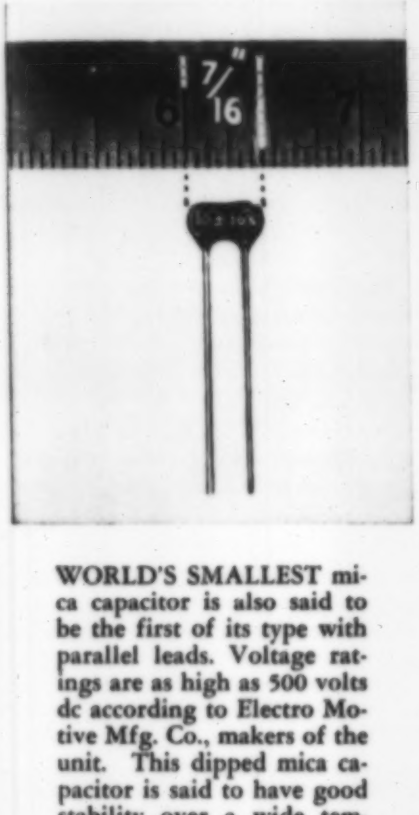
None of the other properties of silicone rubber—aging and weathering resistance, low temperature flexibility, low moisture absorption—are said to have been sacrificed to produce the improved high temperature resistance.



MACHINE DESIGN

"Digby here knows all the angles."

Class 700 materials are suitable for molding, extrusion or calendering fabrication methods. One compound, designated SE-750A, is reported to be particularly suitable for the hot-air technique of curing extruded parts. A wide variety of applications for the new materials is anticipated, such as kitchen oven-door seals and parts for materials-handling equipment in the glass, ceramics and metals industries.

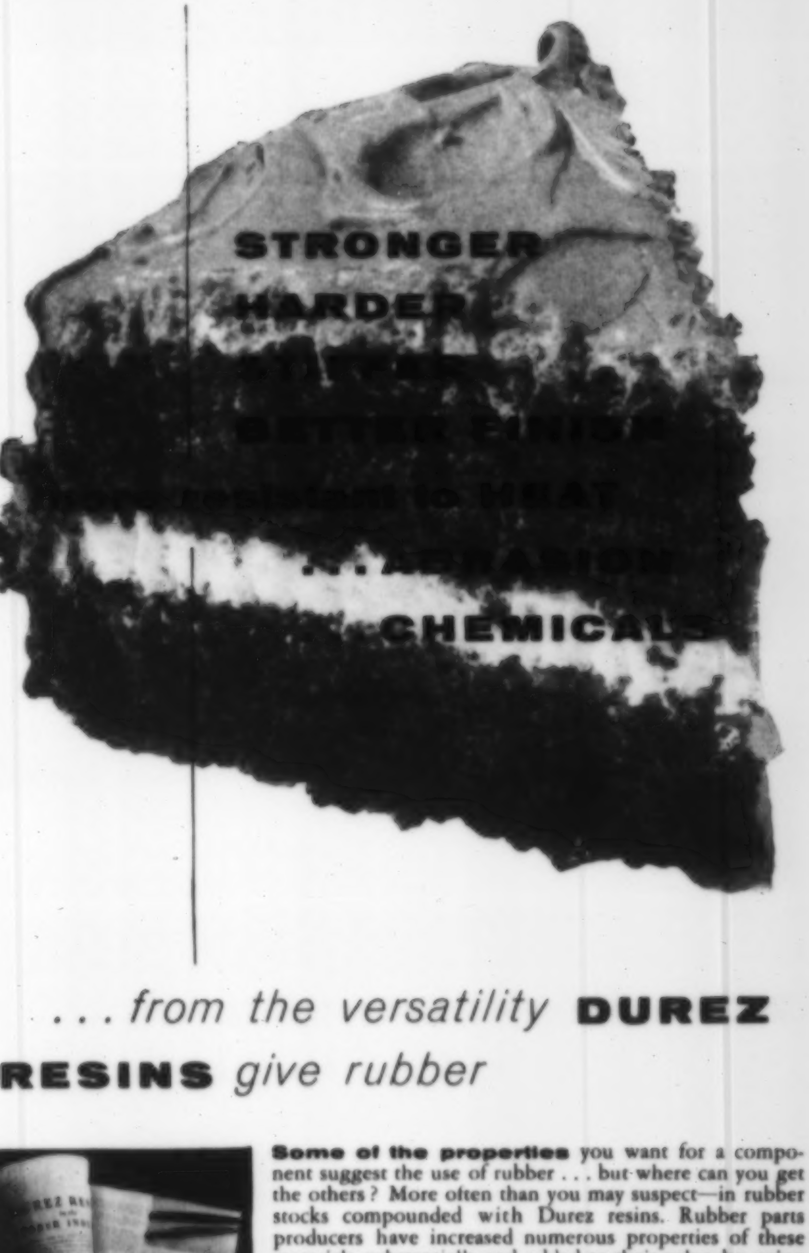


WORLD'S SMALLEST mica capacitor is also said to be the first of its type with parallel leads. Voltage ratings are as high as 500 volts dc according to Electro Motive Mfg. Co., makers of the unit. This dipped mica capacitor is said to have good stability over a wide temperature range

Teer, Wickwire and Co., Jackson, Mich., announce the purchase of the Lindberg Air and Hydraulic Cylinder Div. from Lindberg Engineering Co., Chicago.

De Laval Steam Turbine Co. has announced a long-range expansion program. Land has been purchased for future construction of new buildings in Trenton, N. J. and

Cut your product a slice of BENEFITS



... *from the versatility* **DUREZ RESINS** *give rubber*

Some of the properties you want for a component suggest the use of rubber . . . but where can you get the others? More often than you may suspect—in rubber stocks compounded with Durez resins. Rubber parts producers have increased numerous properties of these materials substantially and added to their value by using Durez with nitrile, GRS and other stocks.

We have prepared a bulletin showing much that you'll want to know on this subject. No industrial library is complete without it, and we'll be glad to send you a copy.

● *Ask for the newest edition of our bulletin, "Durez Resins in the rubber industry."*

DUREZ PLASTICS DIVISION
HOOKER ELECTROCHEMICAL COMPANY
507 Walck Road, North Tonawanda, N. Y.

DUREZ

PHENOLIC RESINS
for Industry since 1921

Everyone recognizes this
as a sign of summer...

And smart gear users know
this CINTI is the sign of good gears
made to your specifications.

May We Send You Our Brochure?

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THE CINCINNATI GEAR CO. • CINCINNATI 27, OHIO

ILSCO CONNECTORS
MAKE YOUR PRODUCT PERFORM BETTER

All these . . . and more . . . for
YOUR BEST CONNECTIONS

U/L AND CSA TESTED
PURE COPPER
100% CONDUCTIVITY
COOLER OPERATION

HI-RUGGED STRENGTH
RE-USABLE
ALL WIRE SIZES
ECONOMICAL

WRITE FOR
80-PAGE CATALOG
•
ILSCO CORPORATION
5752 Mariemont Ave.
CINCINNATI 27, OHIO

Houston, Texas. Specific building plans are already underway on sites acquired near Chicago and San Francisco.

New Synthetic Wax Made of Polyethylene

Rice-size Pellets Permit Easier Handling

Polyethylene wax has recently been announced as a less-expensive substitute for higher cost commercial wax ingredients. Made by Eastman Chemical Products Inc., the new wax is called Epolene.

Two forms of Epolene are said available. One is an emulsifiable type know as Epolene-E. The other, Epolene-N, is nonemulsifiable. Both forms of the new wax are said compatible with nearly all the commonly used animal, vegetable and mineral waxes.

Epolene may be incorporated into basic paraffine mixtures for melt-coating applications. As a result, the final compound is said to have increased resistance to moisture-vapor transmission. Increased hardness, higher melting point and improved dielectric properties are among the other benefits resulting from upgrading paraffine with polyethylene. Its outstanding property is said to be its ability to plasticize other waxes.

New polyethylene wax comes in the form of these rice-size pellets

Tests indicate that Epolene-N

can be used in potting coils, capacitors and other electrical devices because of its good dielectric properties. Other applications include use as a calendar release agent in rubber compounding and as a flattening agent in lacquers.

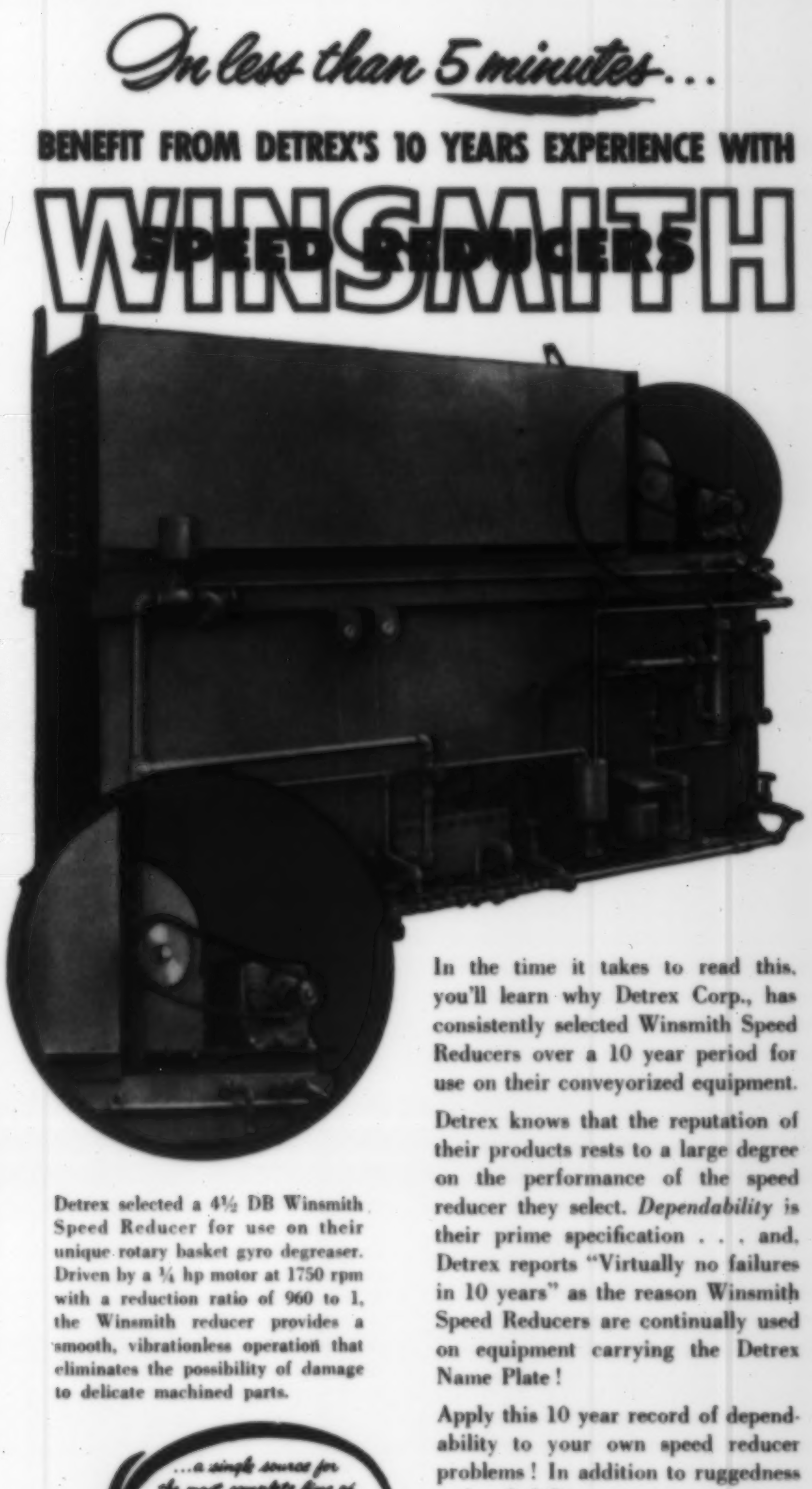
Epolene-E, according to Eastman, is recommended for use in furniture and floor polishes.

Because the new wax is made in the form of rice-size pellets, it can be melted in a relatively short time. Conventional wax blocks are said to require considerably more time to melt than the small pellets.

PLASTIC HORSESHOE shown here is a model of one of two principal bearings which support the Mt. Palomar 200-inch telescope. Purpose of the model is to study the oil-flotation or hydrostatic - lubrication method of reducing friction between the bearing and the mount. According to Westinghouse, designers of the bearing, the 500-ton telescope can be moved by a $1/2$-hp motor

Axelson Mfg. Co., div. of U. S. Industries Inc., Los Angeles, has purchased the Fray line of milling

(*Continued on Page* 42)



In less than 5 minutes...

BENEFIT FROM DETREX'S 10 YEARS EXPERIENCE WITH

WINSMITH SPEED REDUCERS

Detrex selected a 4½ DB Winsmith Speed Reducer for use on their unique rotary basket gyro degreaser. Driven by a ¼ hp motor at 1750 rpm with a reduction ratio of 960 to 1, the Winsmith reducer provides a smooth, vibrationless operation that eliminates the possibility of damage to delicate machined parts.

In the time it takes to read this, you'll learn why Detrex Corp., has consistently selected Winsmith Speed Reducers over a 10 year period for use on their conveyorized equipment.

Detrex knows that the reputation of their products rests to a large degree on the performance of the speed reducer they select. *Dependability* is their prime specification . . . and, Detrex reports "Virtually no failures in 10 years" as the reason Winsmith Speed Reducers are continually used on equipment carrying the Detrex Name Plate!

Apply this 10 year record of dependability to your own speed reducer problems! In addition to ruggedness and reliability, you can count on Winsmith for the most complete line of speed reducers from a single source within the range of 1/100 to 85 hp. in ratios of 1.1:1 to 50,000:1. A Winsmith power transmission specialist is available to discuss your speed reducer applications. You'll find him listed in the classified section of your phone directory; or, write Winsmith, Inc. direct.

...a single source for the most complete line of speed reducers within the range of 1/100 h.p. to 85 h.p. in ratios of 1.1:1 to 50,000:1

WINSMITH SPEED REDUCERS

WINSMITH, INC.
16 Elton St.
Springville, (Erie County) N. Y.

Just to suggest the practically unlimited variety of mounting positions possible with Elliott Crocker-Wheeler right-angle single worm reduction gearmotors.

- a-c or d-c • ½ to 30 hp • foot- or flange-mounted
- with any motor enclosure • for all AGMA service classifications

Your Elliott representative has complete information . . .

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Chicago 30
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Cincinnati 6
2337 Victory Parkway

Cleveland 14
1319 National City Bank Bldg.
Dallas 5
5738 Central Expressway
Denver 9
308 Union National Bank Bldg.
Detroit 26
1820 Dime Bldg.
Duluth
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Houston 3
1209 Hutchins Street
Indianapolis 8
54 West 30th Street
Kansas City 14
514 West 75th Street

Los Angeles 15
714 West Olympic Blvd.
Milwaukee 3
744 North 4th Street
Minneapolis 3
540 Plymouth Bldg.
Newark 7
4th Avenue and 13th Street
New Orleans 13
256 Lee Circle Bldg.
New York 13
271 Church Street
Philadelphia 2
226 South Sixteenth Street Bldg.
Pittsburgh 19
718 Frick Bldg.

Rockford, Ill.
403 Central National Bank Bldg.
Salt Lake City
Zion Savings Bank Bldg.
San Francisco 4
1504 Russ Bldg.
St. Louis 3
1221 Locust Street
Seattle 1
1101 Vance Bldg.
Syracuse 2
317 State Tower Bldg.
Tulsa 3
910 Petroleum Bldg.
Washington 1, D.C.
Washington Gas Light Bldg.

ELLIOTT Company • JEANNETTE, PA.
CROCKER-WHEELER DIVISION

WD-7

Oil Power Helps Manpower Guide Horsepower with EASE!

Arm-weary tractor operators are grateful for TD-14A and TD-18A International Harvester crawlers. They steer with the ease of a late model car for each track is controlled by its own hydraulic circuit…a booster system with velvet smooth, positive action that stems from

HYDRECO
Oil Power

Here is a HYDRECO dual pump that delivers 5 gpm to each circuit at 1200 rpm against a system pressure of 700 psi. The dual pump provides a circuit for each track and the result . . . no arm-weary operators . . . more accomplished with less effort, in less time . . . smoother, higher performance . . . lower maintenance.

For engineers seeking practical answers to problems of trouble-free hydraulic controls, better performance, added functions and greater sales appeal for mobile equipment, the experience of HYDRECO engineers offers a definite answer!

WRITE— *for latest literature and full information on new developments in HYDRECO Pumps, Motors, Valves, and Cylinders.*

HYDRECO DIVISION
THE NEW YORK AIR BRAKE COMPANY
1106 EAST 222nd STREET • CLEVELAND 17 • OHIO
INTERNATIONAL SALES OFFICE, 90 WEST ST., NEW YORK 6, N. Y.

(Continued from Page 39)

machines and milling attachments from the **Fray Machine Tool Co.**, Burbank, Calif.

Trans-American Precision Instrument Corp., has become a member of Sterling Precision Instrument Corp. New official name of Trans-American is Sterling Precision Instrument Corp., Instrument Div.

• • • POWER STEERING *for airplanes has been announced by Warner Electric Brake & Clutch Co. Mounting a drive motor controlled by a stationary-field electric clutch in De Havilland's "Otter" allows power steering of the tail wheel. At the pilot's option, the tail wheel can be made to follow the rudder. Mud or snow sometimes prevents the wheel from turning in the proper direction for taxiing. This system should eliminate the need for digging out mired airplanes.*

Air Force Searches For New Ideas

Proposals Sought For Weapons Applications

Do you have an idea for a new missile? Or a new principle which might revolutionize aircraft design? Or a new material which can stand temperatures that turn ordinary metals to liquid?

The Air Research and Development Command is interested in obtaining new ideas and testing them for possible application in maintaining the qualitative superiority of Air Force weapons.

Proposals submitted should include a description of the innovation with estimates of expected performance. Correspondence should be sent to: Assistant for Innovations, RDTE, Headquarters, Air Research & Development Command, Box 1395, Baltimore 3, Md.

American Brass Co. has announced plans for construction of a $2.5 million plant at Mattoon, Ill., for the manufacture of flexible metal hose and tubing.

Chrome Overcoat Needs No Undercoat

New Process Reduces Plating Imperfections

Chrome plating directly on steel without an undercoat of copper or nickel is said possible with a new process recently developed. Announced by United Chromium Inc., the new plate is deposited free of any structural imperfection that would allow corrosive materials to come in contact with the underlying surface being protected.

Chrome plate deposits less than about 0.0001-inch thick usually contain pores, depending upon plating conditions. As thickness increases, the number of pores decrease. However, a cracked structure develops and continues regardless of increase in thickness. Corrosive substances can filter through these cracks to attack the base metals.

A special chromic-acid type bath with automatic regulation of the catalyst concentration has been developed as a solution to the cracking problem. Standard plating equipment and procedures are used. Plating speed is said to be about the same as that of ordinary chromium.

Tests made by the company show the process to result in chrome plate that will remain crack-free when heated to 1000 F and plunged into water. Another desirable result of the process is a softer, more ductile chromium. This softer chrome plate is said to test at 500-700 Knoop as compared to 800-1000 Knoop hardness for ordinary plate.

One recent application reported by the company consisted of plating a steel washing machine shaft with a ½-mil thickness of chrome in accordance with the new process. After 100 hours' exposure to salt spray, the shaft was said to be practically unaffected.

Other applications are reported to include cold-stamping dies and cam followers. At present, tests are being conducted to determine the possible application of the process to steel machine parts for calculators, hand tools, hydraulic

DUDCO PRESENTS . . .
for MOBILE EQUIPMENT
a New Dual-Vane Pump

SERIES
PFM-100
2000 psi
Continuous Duty
3 to 11 gpm
at 1200 rpm
0 psi

TWO VANES ARE BETTER THAN ONE

The hydraulically counterbalanced DUAL-VANES in DUDCO Hydraulic Pumps eliminate wear producing loads normally caused by unbalanced hydraulic forces and vane acceleration. DUAL-VANES also maintain MULTIPLE SEALING BARRIERS to slippage and power loss. DUAL-VANES are a patented and exclusive DUDCO feature.

This Pump was engineered to meet the special conditions characteristic of service on mobile equipment.

Here is a pump designed for high speed direct engine drive that can be operated *continuously* at *2000* psi and *2000* rpm to meet the continuing demand for more work from your equipment.

The exclusive DUDCO Dual-Vane design provides and assures *complete hydraulic balance* of all internal parts. Bearing loads and cam ring wear are reduced so DUDCO PFM-100 Pumps last longer.

Designing these Pumps into your machines is made easier because all standard S.A.E. or industrial mountings and piping provisions are available, as well as complete flexibility of port positions.

PFM-100 Series Pumps are priced for the competitive mobile equipment market . . . NO price penalty for high pressure equipment.

Write— *for complete information on the new DUDCO PFM-100 Series DUAL-VANE Hydraulic Pump.*

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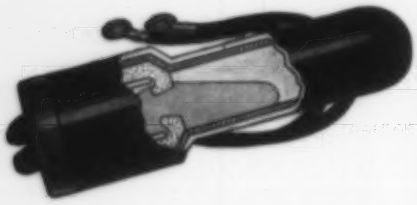
Millions of Contacts without Faltering

PROVED

ON rough, tough jobs



Durakool pressurized all-steel **mercury tilt switches** have more than made good on what may have seemed like extravagant claims a few years ago. The list of Durakool successes grows each year. Seven sizes, 1 to 65 amperes. 3 to 4 weeks delivery. Your production schedule is met.

WITHSTANDS
HIGH
TEMPERATURES

See telephone directory for local distributor or write
® DURAKOOL, INC., Elkhart, Indiana
700 Weston Rd., Toronto 9, Canada

Durakool
ALL-STEEL MERCURY SWITCHES

rams and pistons, and plating of standard steel tubing.

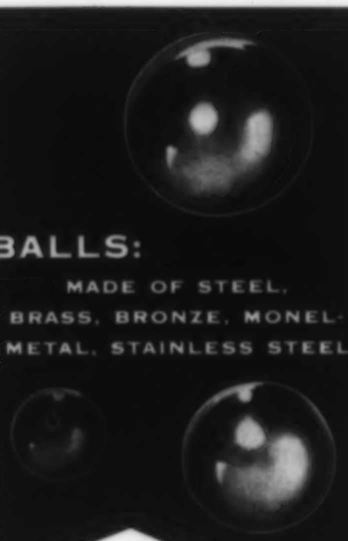
GLASS GAS TANKS of the throw-away variety have been developed by Pastushin Aviation Corp. for aircraft use. Made of thermosetting resin reinforced by chopped glass rovings, the tanks are said to be chemically inert and have high structural efficiency. Shown here is a 200 gallon capacity model. Joints and components are bonded without metallic fasteners and fabricated without welds

Stainless Steel Designations Revised

Additions and Revisions Bring Listings Up to Date

Major changes have been announced in the published designations for stainless steel types by the American Iron and Steel Institute. New additions to the 300 and 400 series now bring the total of standard designations to 35. Changes have also been made in the published analyses for the 501 and 502 heat-resisting steels which are grouped with but not classified as stainless.

Since May, 1954 the Institute has been tabulating data to bring desig-



BALLS:
MADE OF STEEL, BRASS, BRONZE, MONEL METAL, STAINLESS STEEL

HOOVER

The Aristocrat of Bearings

BALL BEARINGS:
AMERICA'S ONLY BALL BEARING WITH HONED RACEWAYS

HOOVER BALL AND BEARING COMPANY
ANN ARBOR, MICHIGAN

nations in line with current practice. The new types and modifications are said to be the result of this task.

Machinability was considered in the new standards with the establishment of three new types—303Se, 416Se and 430F Se. In effect, designers and fabricators now are offered high machinability by a choice of sulphur or selenium additions. Sulphur-bearing stainless steels are reported to be more suitable for deep or heavy cuts while selenium-bearing types are preferred for shallow or light cuts.

Improvements in melting practice and metallurgical control are responsible for many of the analysis changes. Producers have been able to work to closer alloy limits, thus permitting a reduction in the maximum formerly specified for some types. Six types have undergone changes in the maximum allowable carbon content provided for by the standard compositions. These are 301, 302, 302B, 316, 317 and 446.

With the removal of government restrictions on alloys used in making stainless steels, all TS or "Tentative Standard" types have been eliminated. These were TS 316, TS 347 and TS 347A.

TS 316 was established in accordance with NPA Order M52 for the conservation of molybdenum. However, the industry is currently producing 316 and 316L which provide higher molybdenum contents and, as a result, increased corrosion resistance for certain applications.

TS 347 and TS 347A were also established under NPA directives to conserve strategic columbium resources. Columbium ores contain small quantities of tantalum, and since both elements have the same effect in stabilizing stainless steels, their total content can be considered jointly in its ratio to carbon content. The maximum limit of their content in TS 347A was established by NPA order M-3 as no more than eight times the carbon content. Columbium alone in the TS 347 alloy was also set as eight times the carbon content. In place of these types, a modification of 347 and the new type 348

(*Continued on Page* 48)

OFTEN

TWO HEADS ARE BETTER THAN ONE

Sometimes two heads are the only solution to a part or fastener problem. Take a quick look at the belt buckle roller illustrated. This was a really special job and it solved a special problem for both the Armed Services and their suppliers. The big problem here was to produce this roller in *quantity, inexpensively* and *quickly* . . . and HASSALL double-heading did the trick.

Double-heading is only one example of the almost limitless possibilities Hassall cold-heading offers you. If you have a fastener problem just send us samples or specifications for a quotation.

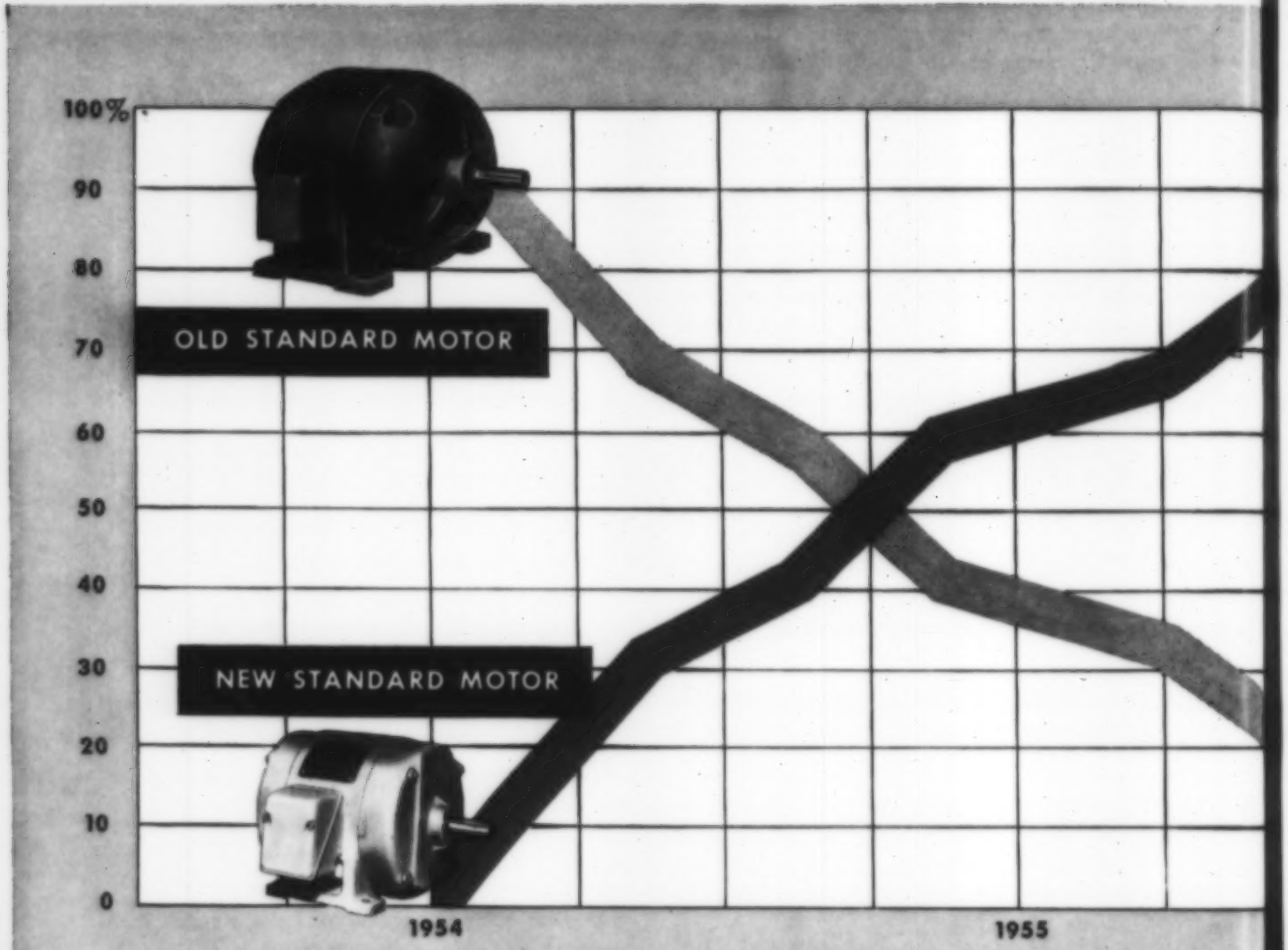
WRITE FOR CATALOG . . . with it we will send our popular decimal equivalent wall chart.
John Hassall, Inc., Box **2197,** Westbury, L. I., N. Y.

HASSALL

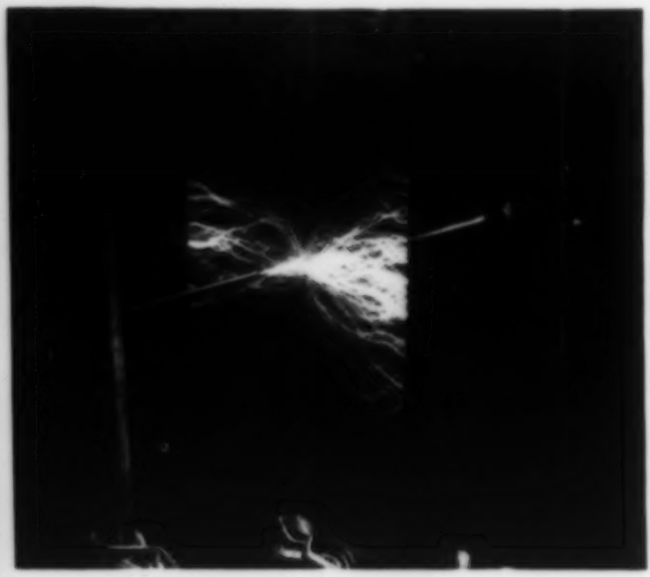
SINCE 1850

Hassall

NAILS, RIVETS, SCREWS
AND OTHER COLD-HEADED
FASTENERS AND SPECIALTIES



G-E SALES FIGURES SHOW THAT MOST CUSTOMERS HAVE STARTED CONVERSION BY SPECIFYING THE NEW STANDARD MOTORS FOR REPLACEMENT AND ON NEW EQUIPMENT.



NEW "MIRACLE" INSULATION, polyester film, is shown at left withstanding a tremendous high voltage blast. The insulation used in most ordinary motors (right) burned out at about one-third that amount of voltage. Tests like this one show why the new G-E Tri-Clad '55' lasts longer than ordinary motors.

Progress Is Our Most Important Product

GENERAL ELECTRIC

50% MORE POWER for their new centerless grinder was realized by the Van Norman Co., Springfield, Mass., when they switched to G.E.'s new motor. The new 7½-hp motor fitted in the space formerly occupied by a 5-hp motor.

ARE YOU TAKING ADVANTAGE OF THE BIG 'MOTOR SWITCHOVER?'

Brand-new standards for 1 to 30-hp motors, proposed by motor manufacturers (NEMA) in 1953, have already been accepted by more than 75% of American industry.

The major factor behind this rapid switchover is that motor buyers are now taking advantage of the longer life, lower maintenance, and better performance afforded by the new motors. Machine performance can be improved with the new G-E Tri-Clad* '55' motor, because of its higher full-load operating speeds.

Users are also getting longer life out of the new G-E motors, because of the new insulation which is 8 times stronger than ordinary motor insulation. Maintenance has been greatly reduced through the use of a new synthesized grease with 4 times greater lasting power, and permanumbered leads which can be identified even when taped or clipped.

Are you investing in motor progress or motor obsolescence? You can take advantage of all these latest improvements if you specify G.E.'s new Tri-Clad '55' motor. Contact your G-E Apparatus Sales Office or authorized G-E motor supplier today. *General Electric Co., Schenectady 5, New York.* 648-28

*Reg. trademark, General Electric Co.

"BEST PERFORMING MOTOR that G.E. ever built," says W. J. Conery, chief design engineer of F. E. Myers & Bro. Co., Ashland, Ohio, about the new G-E Tri-Clad '55' motor. Higher full-load speed, smaller size and weight, and modern appearance permitted Myers to reduce size and improve performance of their Centri-thrift (left) and Ejecto (right) pumps.

"FAR EASIER TO OPERATE because of the new motor frame sizes," reports Stephen Bader & Company, Valley Falls, N. Y., in behalf of their new "Space-Saver" polishing machine. The 22% weight reduction in the 2-hp G-E Tri-Clad '55' motor allowed the machine to be redesigned for easier "one-man" handling. Higher full-load speeds permitted improved performance.

Progress Is Our Most Important Product

GENERAL ELECTRIC

Now—all from one source

➸ VARI-SPEED MOTOR PULLEY
➸ ADJUSTABLE MOTOR BASE ➸ VARI-SPEED BELT
➸ RELIANCE Ac MOTOR ➸ DRIVEN PULLEY

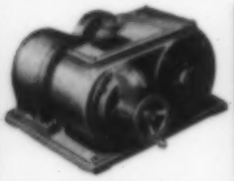
eight sizes
for 1/8 to 15 hp.
2:1 to 4:1 ratio

REEVES
Vari-Speed Motor Pulley

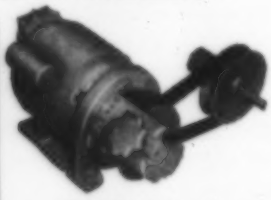
➸ This simple, compact REEVES unit provides an economical way to widen machine range, and an efficient method of adjusting work flow to changing conditions. Speed variations are effected smoothly and instantly—without stopping the machine! Unit also available without motor. For bulletin complete with rating charts and dimensions, write Department H18-V545.

THE RIGHT SPEED FOR EVERY NEED!

Transmission
Heavy duty—2:1 to 16:1 range—fractional hp. to 87 hp.



Vari-Speed Motodrive
Compact—2:1 to 6:1 range—sizes to 40 hp.—fractional with 10:1.



Flexi-Speed
Versatile, economical—8:1 range—½, ¾ and 1 hp.

The wide range of REEVES variable speed equipment is now supplemented by the line of Reliance drives. Now—more than ever—you can rely on your REEVES representative for the answer to any speed control problem.

REEVES PULLEY COMPANY, COLUMBUS, INDIANA
Division of RELIANCE Electric and Engineering Co.

News Roundup

(Continued from Page 45)

are being used.

Other significant changes in chemical composition are the result of the need for greater flexibility in nickel-carbon and chrome-carbon ratios. Six types underwent changes as a result—304, 304L, 317, 321, 347 and 405.

The preceding changes are said to be the result of improved industry practices. These modifications are expected to provide greater flexibility in the use of each type.

FAST HARDENING of gears, cams and tools is accomplished by painting on a new steel-hardening compound. Called Armor-Tuf, the new liquid coating is said to give hardness as high as 60 Rockwell C at a depth up to 0.0010-in. in a few minutes

Midwest Research Institute has opened a new research center in Kansas City, Mo. A staff of 245 is presently employed at the center.

Consolidated Engineering Corp. is building a $1.5-million research, engineering and marketing building on an eight-acre site adjoining the main plant in Pasadena, Calif.

Aluminum Co. of America has announced the start of installation of the widest hot sheet rolling mill ever designed and built for the aluminum industry. The new 160-inch mill will permit the use of much larger ingot, making possible wider aluminum sheet and plate. The $20-million installation will be in full operation in two years.

Meetings
AND EXPOSITIONS

Aug. 22-23—
Symposium on Electronics in Automatic Production to be held at the Sheraton-Palace Hotel, San Francisco, Calif. Sponsored by the Stanford Research Institute and the National Industrial Conference Board. Additional information may be obtained from the Public Relations Dept., Stanford Research Institute, Stanford, Calif.

Aug. 24-26—
Western Electronic Show and Convention to be held at the Civic Auditorium, San Francisco, Calif. Additional information may be obtained from Mal Mobley, Jr., Business Manager, 344 North La Brea Ave., Los Angeles 36, Calif.

Sept. 6-17—
National Machine Tool Builders' Association Show to be held at the International Amphitheatre, Chicago, Ill. Additional information may be obtained from Clapp & Poliak Inc., 341 Madison Ave., New York 17, N. Y.

Sept. 6-17—
Production Engineering Show to be held at Navy Pier, Chicago, Ill. Additional information may be obtained from Clapp & Poliak Inc., 341 Madison Ave., New York 17, N. Y.

Sept. 6-17—
Metalworking Machinery & Equipment Exposition to be held at the Chicago Coliseum, Chicago, Ill. Managing director is William H. Eisenman, 2689 East Overlook Road, Cleveland 6, O.

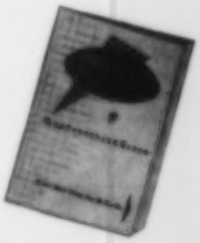
EAGLE
CYCL-FLEX reset timer

for machine control panels
Cycl-Flex
EAGLE SIGNAL

Insures dependable operation and simplified control circuits

Designed with a sealed dial that covers the elapsed time indicator, the Cycl-Flex Timer permits direct mounting to machine panels that are exposed to oil and dust. Timer switches control four load circuits. Interlocking contacts provided without the use of auxiliary relays. Synchronous motor drive insures accurate timing.

The Cycl-Flex is one of the Eagle family of timers designed to fit into every industrial time control need. Eagle sales engineers, located in 30 principal cities, will analyze your timing applications without obligation.



FREE AUTOMATION BOOKLET

MAIL COUPON TODAY!

EAGLE

Eagle Signal Corporation
Industrial Division, Dept. MD-755
Moline, Illinois

Please send Bulletin 120 containing complete data on the Cycl-Flex Reset Timer and free automation booklet, "See What Timing Can Do for You."

NAME AND TITLE
COMPANY
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CITY ZONE STATE

MECHANICAL INTEGRATORS

from FORD INSTRUMENT

for extreme accuracy in computing and variable speed applications

- STANDARD INTEGRATORS in 2½" and 5" disk diameters

FOR EARLY DELIVERY

- and a variety of SPECIALS, such as component and tangent integrators.

Ford Instrument's standard mechanical integrators utilize the Company's two-ball and disk low-friction design. Supplied with a patented ball roller tilt device which minimizes ball slip for all carriage positions, these integrators are high precision units for a wide variety of computing and variable speed drive applications.

FREE — Fully illustrated data bulletin gives specifications and performance information. Please address Dept. MD.

47

FORD INSTRUMENT COMPANY
Division of Sperry Rand Corporation
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Ford Instrument's standard components

Rate Generators
Differentials
Servo Motors
Telesyn Resolvers
Integrators
Telesyn Synchros

Engineering News Roundup

Sept. 12-16—

Illuminating Engineering Society. National Technical Conference to be held at Hotel Statler, Cleveland, O. Additional information may be obtained from Charles Amick, Conference General Chairman, General Electric Co., Nela Park, Cleveland, O.

Sept. 15-18—

Packaging Machinery Manufacturers Institute. Annual meeting to be held at The Homestead, Hot Springs, Va. Additional information may be obtained from society headquarters, 342 Madison Ave., New York 17, N. Y.

Sept. 26-29—

Association of Iron and Steel Engineers. Annual convention to be held at the Sherman Hotel, Chicago, Ill. Additional information may be obtained from society headquarters, 1010 Empire Bldg., Pittsburgh 22, Pa.

Sept. 28-29—

Industrial Electronics Conference to be held at Rackham Memorial Auditorium, Detroit, Mich. Sponsored by the American Institute of Electrical Engineers and the Institute of Radio Engineers. Additional information may be obtained from the American Institute of Electrical Engineers, 33 West 39th St., New York 18, N. Y.

Oct. 3-5—

National Electronics Conference to be held at Hotel Sherman, Chicago, Ill. Sponsored by the American Institute of Electrical Engineers, Illinois Institute of Technology, Institute of Radio Engineers, Northwestern University and the University of Illinois. Additional information may be obtained from J. Kocik, Publicity Committee Chairman, c/o Illinois Bell Telephone Co., 208 W. Washington St., Room 300, Chicago 6, Ill.

Oct. 3-7—

American Institute of Electrical Engineers. Fall General Meeting to be held at the Morrison Hotel Chicago, Ill. Additional information may be obtained from society headquarters, 33 West 39th St., New York 18, N. Y.

Oct. 6-8—

Society of Industrial Designers. Eleventh Annual Meeting and Design Conference to be held at The Woodner Hotel, Washington, D. C. Additional information may be obtained from society headquarters, 48 East 49th St., New York 17, N. Y.

Oct. 17-21—

National Metal Congress and Exposition to beheld at Commercial Museum and Convention Halls, Philadelphia, Pa. Sponsored by the American Society for Metals. Additional information may be obtained from society headquarters, 7301 Euclid Ave., Cleveland 3, O.

Oct. 23-26—

American Gear Manufacturers Association. Semiannual meeting to be held at the Edgewater Beach Hotel, Chicago, Ill. Additional information may be obtained from society headquarters, One Thomas Circle, Washington 5, D. C.

Oct. 24-25—

Steel Founders' Society of America. Fall meeting to be held at The Greenbrier, White Sulphur Springs, W. Va. Secretary is George K. Dreher, 920 Midland Bldg., Cleveland 15, O.

Oct. 24-26—

Sixth National Conference on Standards to be held at the Sheraton-Park Hotel, Washington, D. C. Sponsored by the American Standards Association and the National Bureau of Standards. Additional information may be obtained from American Standards Association, 70 East 45th St., New York 17, N. Y.

Oct. 27-28—

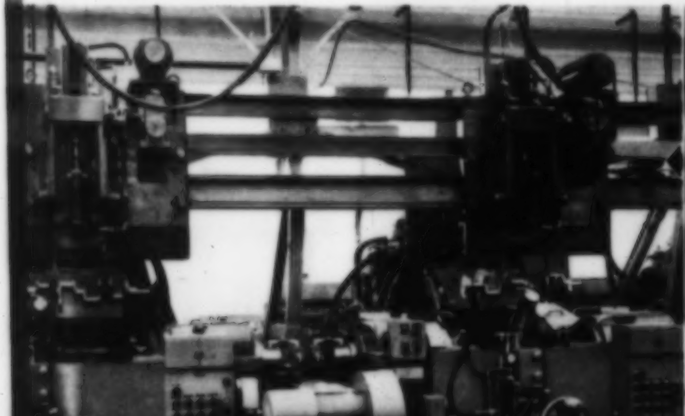
National Conference on Industrial Hydraulics. Eleventh annual meeting to be held at the LaSalle Hotel, Chicago, Ill. Sponsored by the Illinois Institute of Technology and Armour Research Foundation in co-operation with engineering societies and industrial organizations. Additional information may be obtained from C. A. Arents, Secretary, Illinois Institute of Technology, Technology Center, Chicago 16, Ill.

Sundstrand Fluid Motors withstand severe starting and stopping torque in new Norton Crankpin Grinder

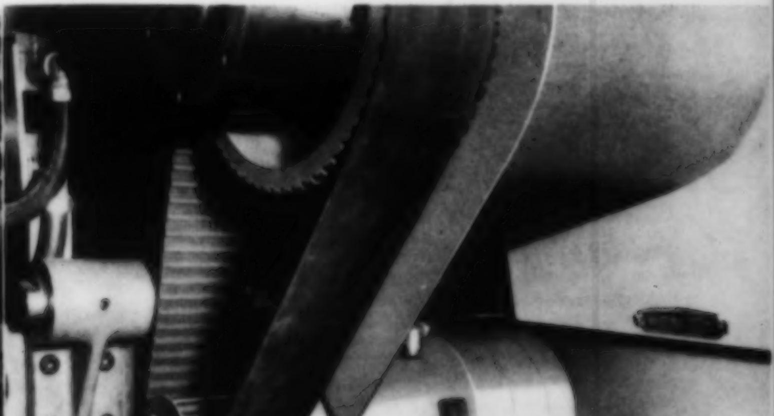
SUNDSTRAND

New Norton Transfer-Type Crankpin Grinder precision grinds all pins on an automotive-type crankshaft automatically at a rate of one complete V-8 shaft per minute. Output is equal to 4½ to 6 semi-automatic grinders with operators.

Sundstrand Fluid Motor provides high torque, infinite control of speed, and reliable performance over long life. Models available from 13.65 to 30.00 hp.



Two **Sundstrand Fluid Motors** accurately position the four workheads to receive and discharge crankshafts. Third motor traverses the transfer mechanism, moving shafts from station to station.



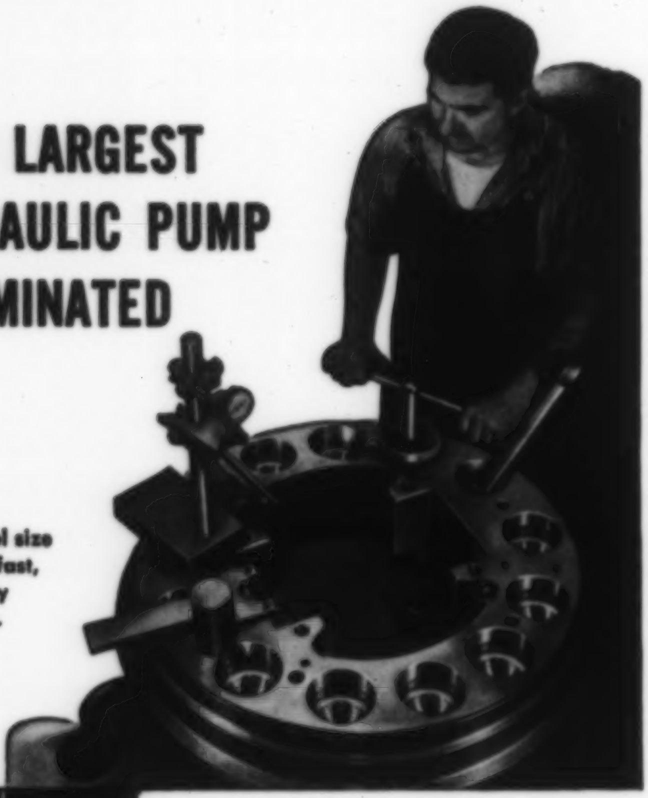
Severe starting and stopping torque are taken in stride by Sundstrand Fluid Motors. Small, compact design simplifies mounting. Get complete Data Bulletin 113-2—let us help you apply Fluid Motors to your product.

SUNDSTRAND HYDRAULIC DIVISION

. . . a division of Sundstrand Machine Tool Co., 2210 Harrison Ave., Rockford, Illinois

FUEL UNITS • FLUID MOTORS • STACK VALVES • LUBE PUMPS

WORLD'S LARGEST OIL HYDRAULIC PUMP USES LAMINATED SHIMS



New Waterbury Tool size "300" pumps gain fast, accurate fit and easy service adjustments.

Heart of this huge 20-ton hydraulic pump is the immense revolving assembly of angle plate, connecting rods and pistons. Tilting the angle plate permits rapid reversing under heavy load. Both ends of the connecting rod bearings – at angle plate and pistons – are assembled and adjusted with Laminated Shims. Shown in large picture is angle plate being assembled. Smaller picture gives size of complete revolving assembly. Pumps will be used in Tube Reducing Machine being built by E. W. Bliss Co. for the Tube Reducing Corp.

The largest oil hydraulic high pressure pumps ever built presented a host of new engineering problems—but the old, familiar problems of fast accurate assembly and easy service adjustments were solved by the old familiar remedy . . . *laminated shims!*

For laminated shims in steel, stainless steel, brass, aluminum and combinations of metals call us first! Forty years of shim engineering experience are at your service! Please write for further information and our new catalogue, yours without cost or obligation.

Simply P-E-E-L for adjustment.

SHIM HEADQUARTERS SINCE 1913

Check Our Stampings Division
For Your Stamped Parts Requirements

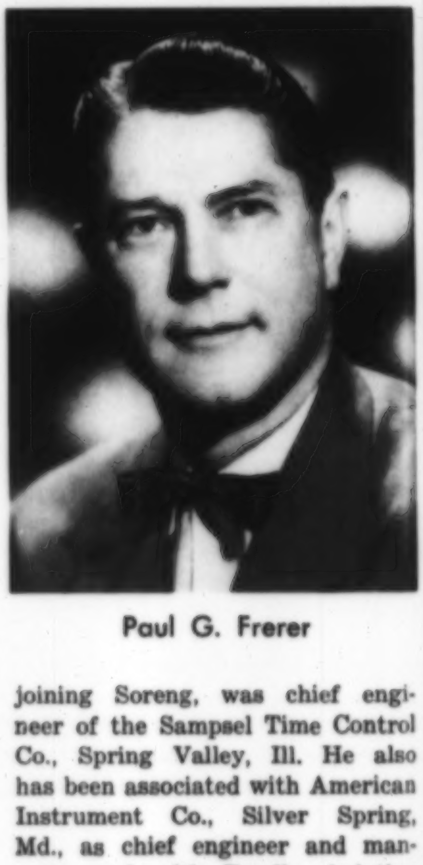
LAMINATED SHIM COMPANY, INC.

1207 UNION STREET · GLENBROOK · CONNECTICUT

MEN

OF MACHINES

Paul G. Frerer has been appointed vice president-director of engineering of Soreng Products Corp., Schiller Park, Ill. Previously he was chief engineer. Mr. Frerer is a graduate of Rensselaer Polytechnic Institute and, prior to joining Soreng, was chief engineer of the Sampsel Time Control Co., Spring Valley, Ill. He also has been associated with American Instrument Co., Silver Spring, Md., as chief engineer and manager, and with Bendix Aviation Corp. in Baltimore and the Perfex Co., Milwaukee.



Paul G. Frerer

Frank W. Fink has joined Ryan Aeronautical Co., San Diego, Calif., as vice president and chief engineer. For 20 years he has been associated with the San Diego division of Convair and before that was on the engineering staff of Curtiss Aeroplane and Motor Co.

S. L. Crawshaw has been appointed to the position of assistant to the president of the Philadelphia Gear Works Inc., Philadelphia. Mr. Crawshaw's experience in the gearing industry includes association with the Nuttall Works of Westinghouse Electric Corp., Pittsburgh; Western Gear Works, Lynwood, Calif.; and, most recently, Amgears Inc., Chicago. Author of numerous technical articles, including the Gearing Section of the Twelfth Edition of *Kent's Mechanical Engineers' Handbook,* he is also an active member and a past president of the American Gear Manufacturers Association.

Paul S. Dickey, formerly vice president and a director, has been elected president of Bailey Meter Co., Cleveland. He succeeds **Robert S. Coffin,** who was elected chairman of the executive committee and named management consultant. At the same time, **Harvard H. Gorrie,** formerly chief engineer, was elected vice president in charge of all engineering activities, and **Raymond D. Junkins,** head of the patent department, was elected a vice president and director.

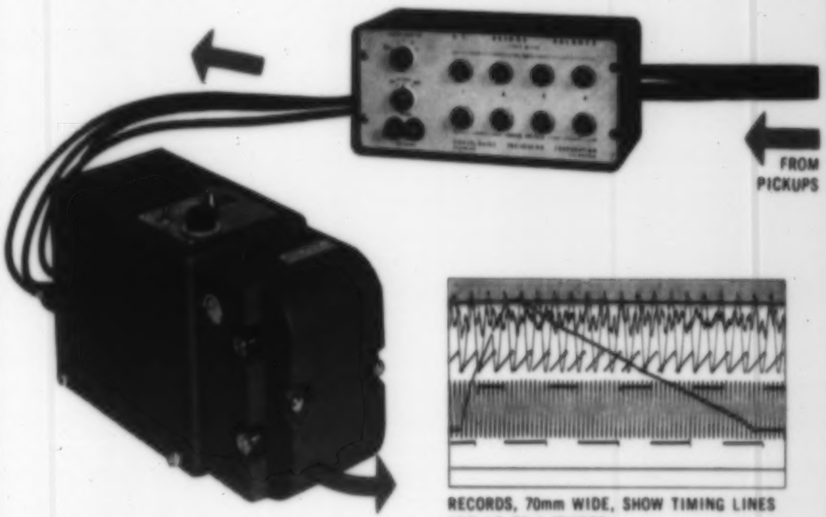
Mr. Dickey joined Bailey Meter as a cadet engineer upon graduation from Purdue University in 1925. After three years he was assigned to the engineering and research department and since that time has served as chief research engineer, marine control consultant and chief engineer. He was elected a vice president in 1947. In 1953 Mr. Dickey received the honorary degree of Doctor of Engineering

Paul S. Dickey

To test your product dynamically...

here's a new high in flexibility... a new low in cost

This simplified, low-cost test equipment should be in every engineering department. It fills the long-standing gap between pen-type recorders and complex oscillograph/amplifier systems... provides a high-speed graphic record of the physical conditions that affect the life of your product. Stress, strain, pressure, vibration, temperature... you can measure them all *at the same time*. And these small, lightweight instruments can be carried anywhere... little experience is required for their operation.



RECORDS, 70mm WIDE, SHOW TIMING LINES AND UP TO 6 TRACES.

S-117 RECORDING OSCILLOGRAPH ... records up to 6 channels of data *without amplifiers* at frequencies to 200 cps (with amplifiers, to 3000 cps). Uses 70-mm by 100-ft paper or film, driven ¾" to 24"/sec. Timing lines appear every 1/100 second. Bulletin CEC 1533A-X 9.

S-110 STRAIN-GAGE BRIDGE BALANCE ... 4-channel control link between oscillograph and strain gages or resistance-type pickups. Has controls for balancing and adjusting d-c voltage across each channel and provision for calibration resistor. Send for Bulletin CEC 1560-X 4.

Consolidated Engineering
Corporation

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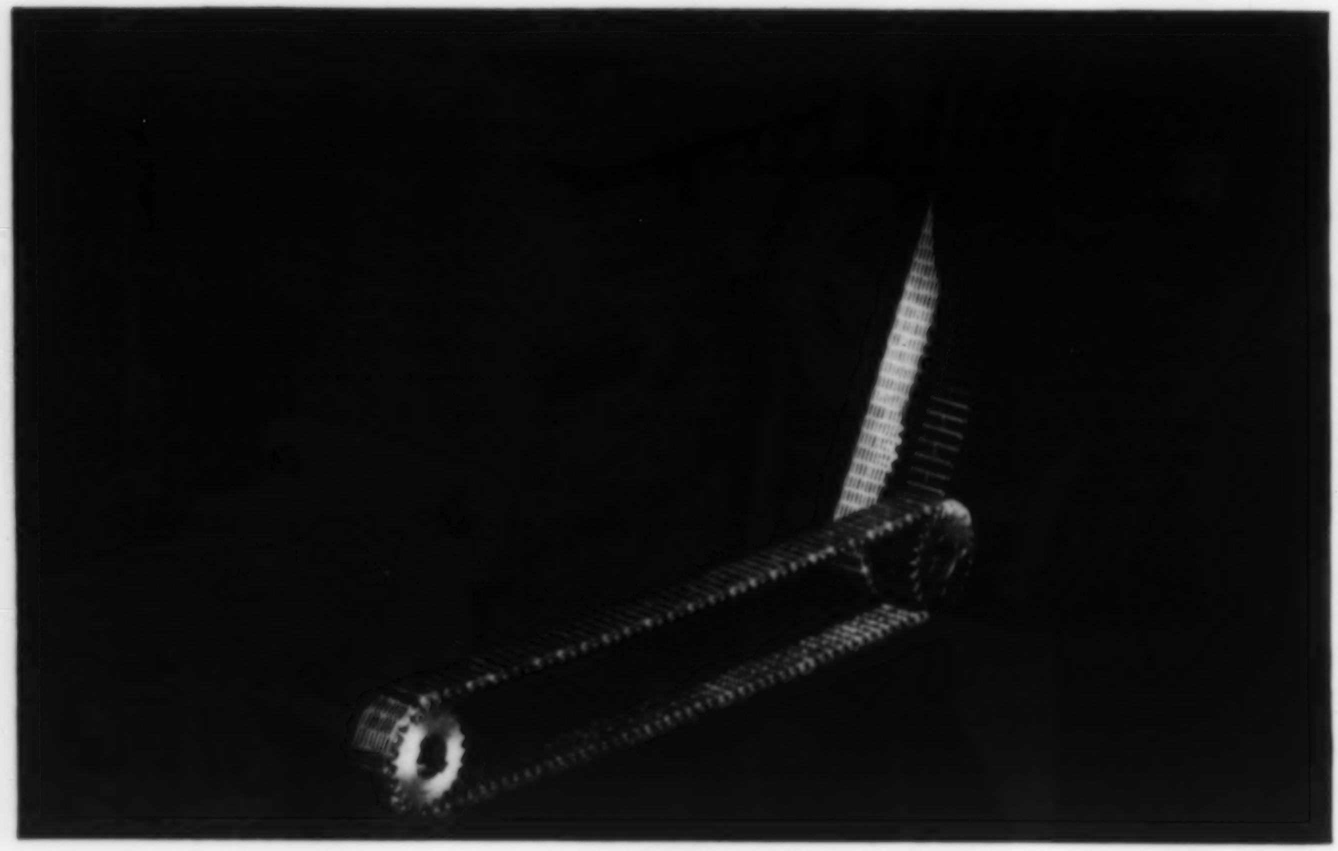

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MORSE BW **CHAINS, CLUTCHES, AND COUPLINGS**

Harvard H. Gorrie

from Purdue. A registered professional engineer, he is a member of the American Society of Mechanical Engineers, the Cleveland Engineering Society, the Instrument Society of America, the executive committee of the Recorder-Controller Section of the Scientific Apparatus Makers Association, the Society of Naval Architects and Marine Engineers, the American Society of Naval Engineers, Sigma Xi and Pi Tau Sigma.

Mr. Gorrie joined the company after graduating from Rensselaer Polytechnic Institute in 1927. In 1944 he was made head of the design department. He was appointed assistant chief engineer the following year and became chief engineer in 1953. Mr. Gorrie is a registered professional engineer and a member of the American Society of Mechanical Engineers, the American Society for Testing Materials, the Instrument Society of America, the Board of Governors of the Cleveland Engineering Society, the Scientific Apparatus Makers Association and Sigma Xi.

McDowell Co. Inc., Cleveland, has announced the appointment of **Patrick V. Gallagher** as chief engineer of the firm's Dwight-Lloyd Div.

Norman Gray has been appointed staff assistant to the president, and **Eric Bylund** has been named director of research and engineering by Schick Inc., Stamford, Conn. Mr. Gray has been with the company for almost 25 years. Mr. Bylund was formerly associated with Modine Mfg. Co., Racine, Wis.

Radioplane Co., Van Nuys, Calif., a subsidiary of Northrop Aircraft Inc., has announced the election of **Stuart E. Weaver** as vice president in charge of engineering and **John R. Jacobsen**, formerly chief engineer, as assistant vice president of engineering.

William G. Patriquin, former research engineer, has been appointed assistant chief engineer of the Gabriel Co., Cleveland. He replaces **William H. Kieber**, who was advanced to the new position of engineering and sales consultant.

Poor & Co. has announced the formation of a new Crusher Engineering Div., with headquarters in Philadelphia. The new division will produce jaw and roll crushers, hammermills, impact breakers, Bradford breakers and pulverizers. Chief design engineer of the division is **F. H. Neely**, who was formerly associated with the Pennsylvania Crusher Co.

T. K. Greenlee, formerly chief electromechanical engineer of the Grand Rapids, Mich., division of Lear Inc., has been appointed division engineering manager. He will direct all phases of the division's engineering operation.

John M. Miller Jr. has been named to the newly created position of director of engineering of the Television and Broadcast Receiver Div. of Bendix Aviation Corp. in Baltimore. **Stanley R. Scheiner** is assistant director of engineering. Both Mr. Miller, who was formerly chief engineer, and Mr. Scheiner joined the Bendix staff eight years ago.

Ralph Aasen has been appointed vice president of engineering by Mark Simpson Mfg. Co. Inc., New York.

Consolidated Engineering Corp., Pasadena, Calif., has appointed **Glyn A. Neff** project chief for data

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processing systems. He will be concerned primarily with data processing systems as they are used in design and testing of atomic reactors, jet engines and guided missiles.

Byron T. Virtue recently was elected to the newly created office of vice president of engineering of Torrington Co., Torrington, Conn. He has been associated with the company since 1945, when he first started as assistant chief bearings engineer, becoming chief engineer of the Bearings Div. a short time later.

Studebaker-Packard Corp., Detroit, has appointed **William M. Schmidt** vice president and director of styling.

Executive vice president of Racine Hydraulics & Machinery Inc., Racine, Wis., **John E. Erskine** was elected president of the National Fluid Power Association at the association's recent annual meeting. Mr. Erskine was active in the formation of the society and served as vice president in 1953 and 1954.

R. H. Carter has been named chief engineer by Miniature Precision Bearings Inc., Keene, N. H. A graduate of the University of New Hampshire in mechanical engineering, Mr. Carter has been associated with the company in an

R. H. Carter

engineering capacity for 16 years. He is a registered professional engineer and a member of the American Society of Tool Engineers and the New Hampshire Society of Engineers. Heading his company's engineering department, he is responsible for all phases of ball bearing engineering, including design and user application services.

Joseph F. Hutchinson recently was appointed manager of the automotive engineering division of Goodyear Tire & Rubber Co., Akron. He succeeds **J. C. Tuttle,** who was named consulting engineer for the division.

Bernard Levine has been appointed director of design and application engineering by Norden-Ketay Corp., New York. He was previously engineering director of the Ketay Laboratories Div.

Worthington Corp., Harrison, N. J., has named **Hellmuth Walter** to the position of director of research to succeed **Ralph M. Watson,** who has accepted an appointment as associate dean of the L. C. Smith College of Engineering and chairman of the department of mechanical engineering of Syracuse University. Born in Germany, Mr. Walter came to this country in 1950 to work as consulting engineer at Worthington's Wellsville Works. In 1951 he was transferred to the Harrison plant.

Robert S. Sherwood, who joined the company in 1951 as a consulting engineer, has been appointed assistant director of research. Mr. Sherwood authored the article, "How to Prevent Oil Film Whirl in Journal Bearings," which appeared in the December 1953 issue of MACHINE DESIGN.

Earl F. Riopelle has been elected vice president in charge of engineering and research for Lunkenheimer Co., Cincinnati. He was a vice president of Houdaille-Hershey Corp.

Philip B. Keller has been appointed vice president in charge of engineering by Stillman Rubber Co., Los Angeles.

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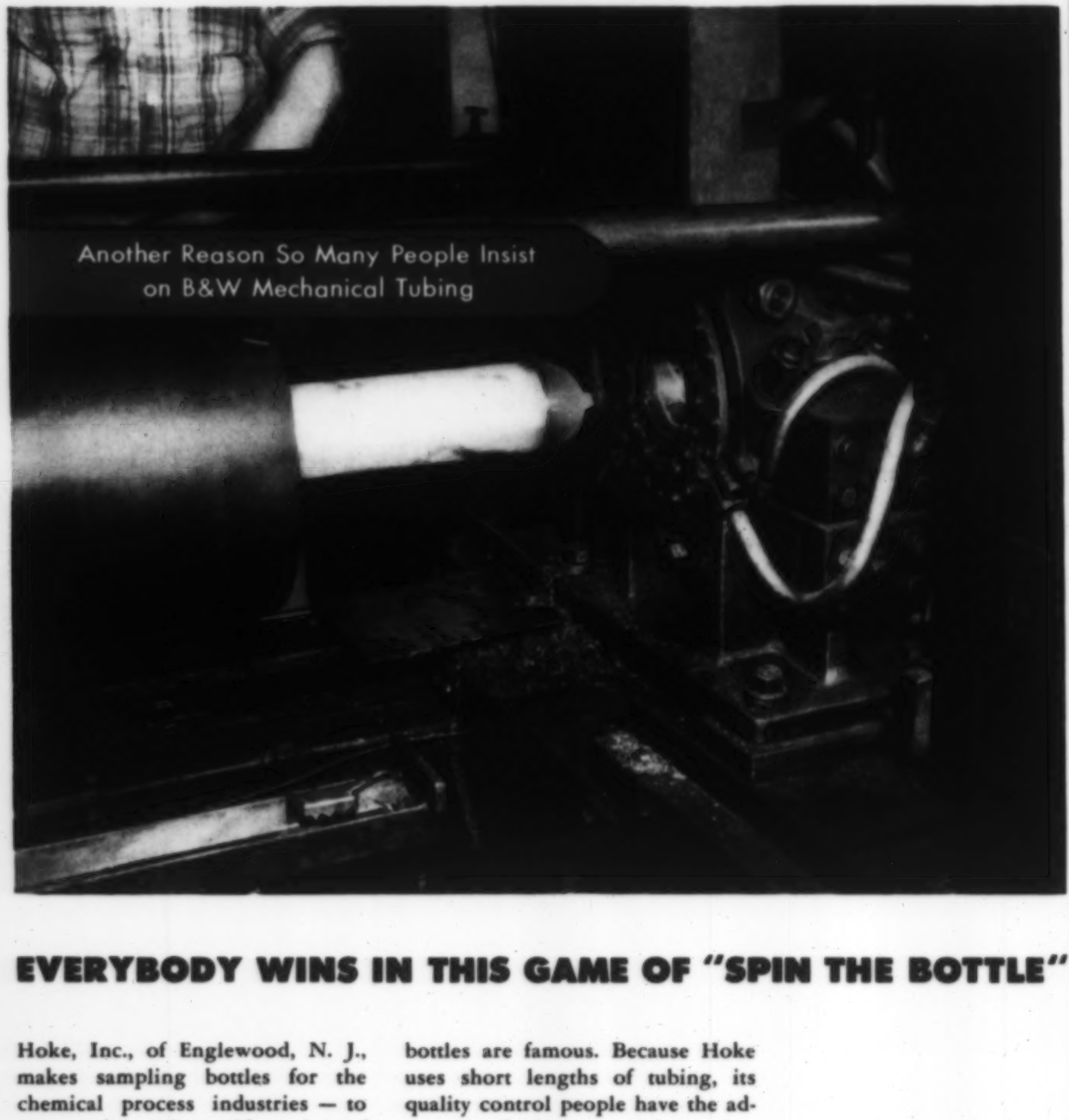

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MACHINE DESIGN

JULY 1955

Chips or Cathedrals

NO small part of a design engineer's total compensation is the satisfaction of achievement. Regardless of whether his employer or the public properly recognizes it, a job well done is itself a rewarding personal experience.

In striving for the utmost efficiency in engineering operations, however, management needs to guard against the danger of removing that powerful incentive. There is a trend toward chopping engineering projects into separate stages, each contained in a watertight compartment. Each engineer is trained as a specialist in one phase and, theoretically, performs more efficiently. Also, he isn't confused by having to consider the scope of the entire project.

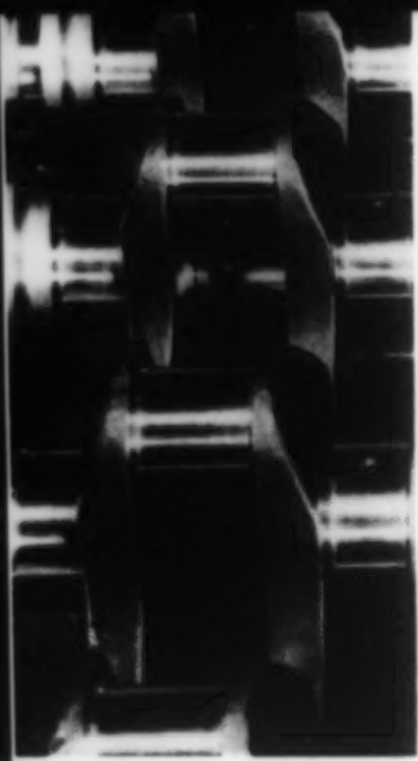
But the theory ignores a human factor which is a vital part of a professional man's makeup—attitude toward the job. The classic story of the three stonecutters illustrates the point. When asked what he was doing, the first man said "Can't you see? I'm knocking chips off a rock." The second said "I'm shaping a stone for a building." But the third man had another answer: "I'm helping to raise a cathedral to the glory of God."

Management can contribute mightily toward development of attitude. The spirit that stimulates a man to put his heart and soul into the job is worth more than all the theoretical organizational devices of the efficiency experts put together.

It is a sad mistake to restrict an engineer's participation in a project to the point where his view of the whole is so limited that he loses his interest and feeling of pride in accomplishment. Good organization must include means for developing both team spirit and a sense of personal achievement in each individual.

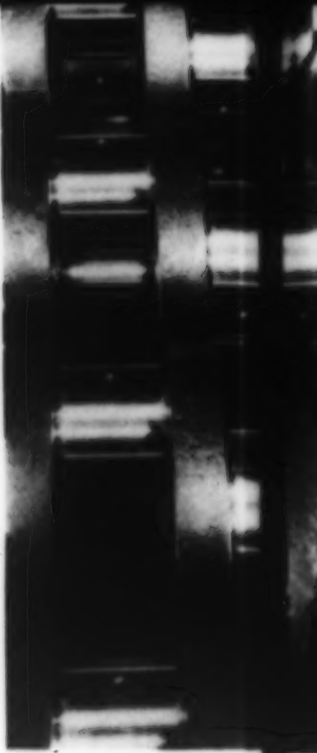
Colin Carmichael

EDITOR



Shaft Finish

. . . its relationship to sleeve bearing life



By J. B. Mohler
Consultant
New Castle, Pa.

SHAFT finish is one of the problems which continually plague the bearing engineer. On critical applications where an engineer is asked for an opinion, the problems of shaft finish and shaft hardness always arise. Recommendations are usually based on experience with a similar set of conditions established from known applications.

Several cases of bearing damage have been known with cast-iron shafts and babbitt bearings where failures were definitely traced to the conditions of the journal surface.In each of these cases the damage was found to depend on the direction of rotation of the shaft. Rotation in one direction was satisfactory, whereas rotation in the opposite direction resulted in failure. Careful study revealed the cause. Slivers of metal dragged out during the grinding operation, *Fig.* 1, would be raised, would plough through the bearing metal, and cause failure when the shaft rotated in a particular direction. Steps leading to failure consisted of displacement of bearing metal and roughening of the shaft, followed by breaking of the oil film and metal-to-metal contact. This resulted in increased friction, overheating and finally melting of the bearing metal or seizure.

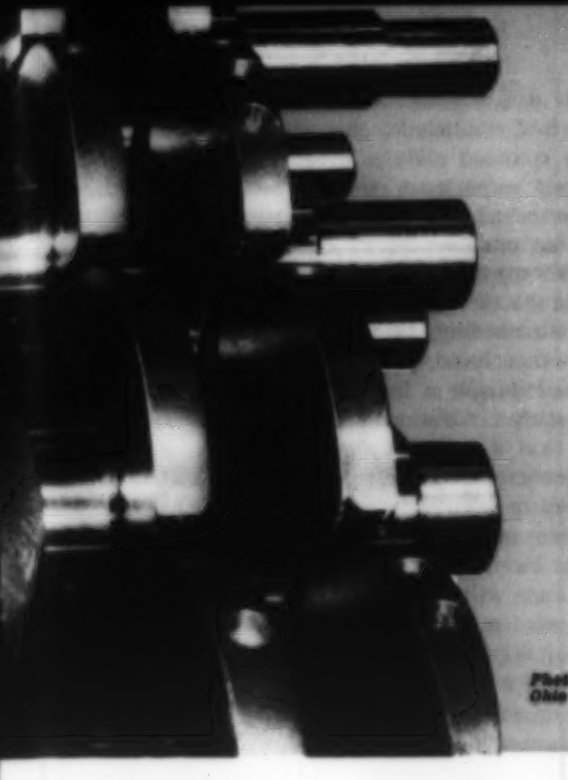
In view of this case it seems likely that failure can be explained on the assumption that the finishing steps may determine whether or not the shaft surface will tend to pick up bearing metal.

Associated Problems: The problem of the shaft cannot be divorced from the problem of the mating part. In the normal relationship, *Fig.* 2, the shaft is supported by a thin film of oil which is maintained on the bearing surface by hydrodynamic lubrication. Thickness of the oil film should be greater than the surface roughness of the metal surfaces in order to avoid metal-to-metal contact. Normally, the bearing is expected to wear and the shaft is expected to resist wear. Relative motion of bearing and shaft is in a direction parallel with the scratches if the bearing is bored and the shaft is ground. If the bearing is broached or burnished, the scratches in the bearing will be perpendicular to the direction of relative motion. Direction of motion, surface roughness and viscosity of the oil will determine the amount of friction, other conditions being the same. Thickness of the oil film should be uniform to properly support the load. Any condition of eccentricity, out-of-round, misalignment or surface waviness will limit the load capacity by increasing the load on localized areas.

Surface roughness of the bearing is a temporary condition, since the bearing will wear in to match the surface contour of the shaft. On the other hand, shaft finish changes very gradually because of wear-resisting properties of the shaft. Shaft finish then exerts an influence for a much longer time than the conforming surface of the bearing.

Shaft finish problems can be overshadowed by inaccurate geometry. Any condition promoting high localized loading may result in premature fatigue failure of the bearing metal, *Fig.* 3. Known conditions and some of the causes for high localized loading are given in *Table* 1. Overall geometry, clearance, fits, tolerance, effects of bolt tensions and percentage of contact area can be determined by inspection, blueing, and measurements with and without the shaft in place. These checks are necessary to assure a uniform oil film thickness or, more properly, to assure the buildup of a wedge of oil under conditions of hydrodynamic lubrication.

When the geometry is proper, then shaft finish



Photo, courtesy The Ohio Crankshaft Co.

Fig. 1—Slivers like that shown at the edge of the graphite flake in this shaft were responsible for bearing failures when the shaft rotated in a certain direction. But no failure resulted when shaft rotation was reversed

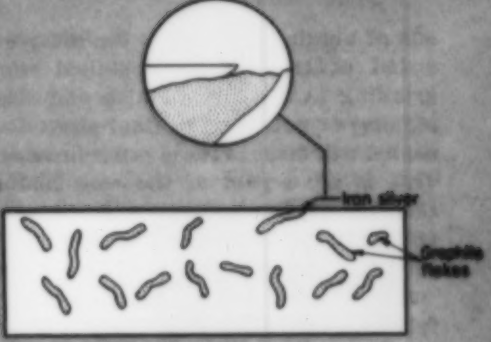
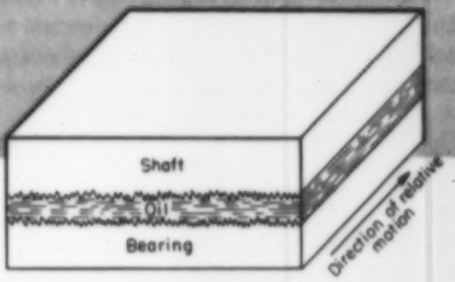


Fig. 2—When normal hydrodynamic lubrication exists, shaft and bearing are separated by a thin film of oil, and no metal-to-metal contact occurs. If surface roughness exceeds oil film thickness, metal-to-metal contact, accelerated wear and failure will result



may become a limiting factor. A simple surface roughness measurement is not necessarily a criterion for satisfaction. The surface may be flat and rough or there may be waviness imposed on the flat surface, *Fig.* 4. This condition may be estimated by proper surface-measuring methods.[1] It is also possible to have an interrupted surface consisting essentially of smooth and flat plateaus with pits and channels dispersed over the surface. Such a surface, *Fig.* 5, may have a high roughness reading and yet be desirable. A surface of this type can be obtained by lapping of a rough chromium-plated surface. Such a surface, known as porous chromium plating, has been successfully used for many years to extend the life of cylinder liners in Diesel engines. Sharpness of a rough surface may also be modified by phosphating, plating, oxidizing, electropolishing or vapor blasting, *Fig.* 6.

A mirror surface is not necessarily desirable, as demonstrated by the fact that oil spreads readily on porous chromium, but not on polished chromium. Also the roughness may help drag the oil along with the moving surface as well as aid in keeping the whole surface wet with oil by distribution through the channels. Possibly more important is the fact that highly polished finishes are expensive, particularly if they are to be accurately produced by mechanical finishing means.

Laboratory Test Evaluation: The importance of shaft finish or method of finishing is not sufficiently understood. Laboratory bearing tests have demonstrated this fact time and again. Accelerated bearing tests are, of course, carried out under critical conditions. Shaft finish is a variable that must be closely controlled. It has been found necessary for fatigue testing, under severe conditions, to standardize the procedure for finishing the shaft. This usually has not been done on a scientific basis, but rather on a trial and error basis. Finishing procedures depended on the skill of particular workmen or on reproducing the prefinishing and final finishing steps. Various meth-

Table 1—Conditions Contributing to High Localized Loading

Condition	Possible Cause
Excess crush	Bearing too large for housing, or excess crush height of half bearings.
Loose bearings	Bearings too small for housing, or insufficient crush height of half bearings.
Out of round	Eccentric bearing wall or distorted housing.
Misalignment	Improper align boring or lack of parallelism between connecting-rod bore and piston-pin bore.
Edge loading	Tapered bore, flexing of shaft due to excessive load on overhung shaft, or insufficient radius on shaft fillets.
Misplaced housing	Housing or cap reversed, misaligned, or from another assembly.
Improper clearance	Wrong size of housing, journal or bearing. Dirt behind bearing back.
Housing yield	Housing too light, or bolts pulled down too tight.
Tapered bore	Poor setup prior to boring.
Flat, barrel-shape or hour-glass journal	Improper grinding of journal.

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[1] References are tabulated at end of article.

ods of obtaining the final desired results have consisted of training of a skilled workman, or of grinding to a definite finish and size, followed by lapping or polishing to final size. Laboratory personnel will discuss these procedures at great length. This is all a part of the case history, indicating that the performance of a shaft can only be guaranteed if the method of finishing is known and experience with the finish has been established.

Other finishing steps which have proved successful shed a little light on the problem. Vapor blasting has been helpful in some cases. This is a case of obtaining better results by roughening the shaft. It has been suggested that such roughening creates millions of tiny pockets for the oil. It is also possible that this finishing method peens sharp microscopic edges.

Chromium-plated shafts have both increased and decreased the tendency to seize. Increased seizure may have been brought about because of a tendency for chromium to weld more readily to bearing metals than will steel. However, under less critical conditions, chromium will tend to deposit as rounded nodules over sharp edges.

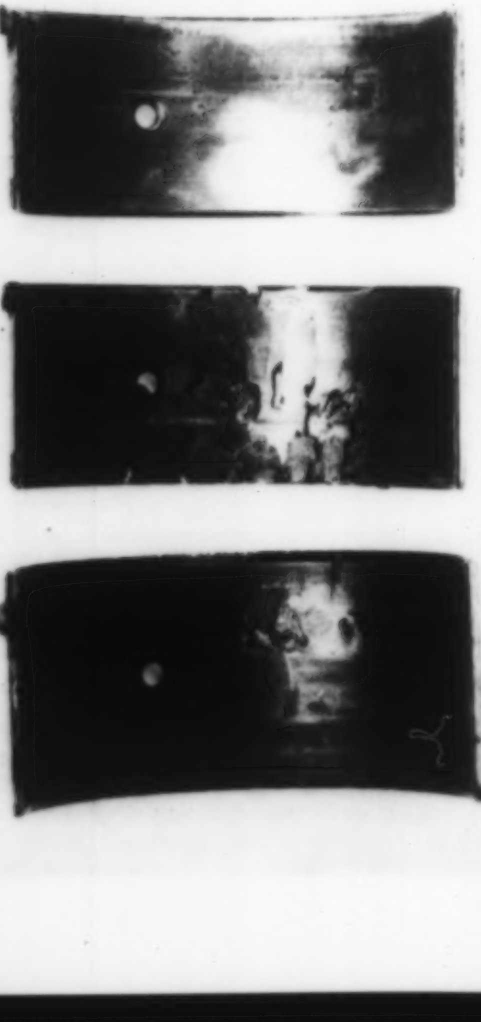

Fig. 3—Excessive damage along the edge of the middle of these three bearing shells indicates that fatigue probably started in these areas, spread over the rest of the bearing and eventually to the other bearings as the high-load area shifted. These are babbitt-lined, steel-backed connecting-rod bearings

Photo, courtesy Johnson Bronze Co.

Another experience that points up this problem has been found during fatigue testing. In more than one laboratory it was found that used journals were less likely to seize than new journals. Even though the used journals showed a higher surface-finish reading, they were less prone to seize. On the other hand, journals that were excessively roughened during a test would seize more readily on retesting. This is really an old experience, namely that a part can be broken in. It should be noted, however, that in this case the journal could be broken in with a new set of bearings and then used more successfully with a second set of new bearings. Eventually a point will be reached where performance will be less reliable rather than more reliable with a new set of bearings, depending on the extent of the change in the journal surface.

Laboratory seizure tests have been notable as failures to obtain reproducible results. Such tests have been set up many times under carefully controlled conditions for material, alignment, speed, load, temperature, type of oil, method of oiling and shaft finish. Speed or load was generally used as a variable and the point of seizure noted. Reproducible results in terms of temperature rise prior to seizure may have been obtained, but results for actual seizure loads were often very erratic. This is not well understood, but is it not a possibility that shaft finish could be the variable that could not be sufficiently reproduced?

Consistent seizure results have been obtained by means of controlled roughness. However this was not done by reproduction of the shaft finish, but rather by injection of a controlled amount of grit. A large batch of grit can be reproducibly made so that an equal quantity will give consistent results on consecutive tests. This may be regarded as a synthetic method of producing surface rough-

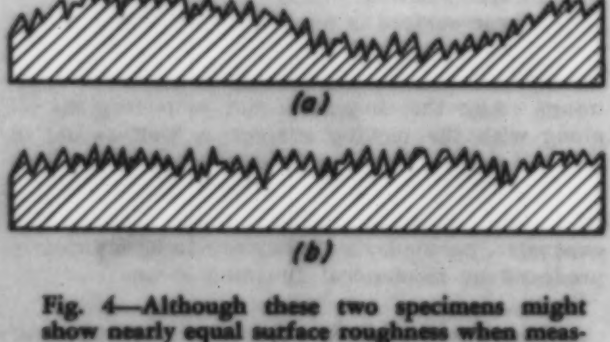

Fig. 4—Although these two specimens might show nearly equal surface roughness when measured, the wavy-rough surface, *a*, is much more liable to rupture the lubricating oil film and cause bearing failure than the flat-rough surface, *b*. Less contact area and therefore, higher pressures are obvious results of the wavy surface

ness. Consistent results were obtained in terms of wear and temperature rise by such testing means.[2]

Bearing Material Effects: In view of these case histories, what can be done about shaft finishing? First it must be said that shaft finish is not a problem except in critical cases. Secondly, it should be said that shaft finish is not necessarily the critical factor where capacities are pushed to the limit. The bearing material, the construction and the oil are all partners with the shaft in the successful application. These other factors should then be considered.

Literature on all the common bearing materials is available to be used as a general guide.[3] The type and finish of the journal can be varied considerably, depending on the application and the bearing material.

In any sleeve bearing application an adequate oil supply of the proper viscosity must be provided. The problems of introduction of the oil, oil grooving, spreading of the oil over the surface, outlet of the oil and the use of mud pockets are well understood. The relative load, speed, wear, fatigue and seizure capacities of the bearing materials are also known.

Shaft applications can be classified as mild, intermediate and severe. For mild applications the babbitts are used. These lead and tin alloys are kind to the shaft. Shaft finish and hardness, and even alignment, are not as critical as for the harder bearing materials. The babbitts will conform readily, embed dirt, and tolerate roughness. Also they present a low-friction surface and have very little tendency to seize. This, of course, is only speaking relatively, since good engineering is required to use these materials to the limit of their capacity, but they have a good tolerance for mild abuse in terms of dirt, roughness or slight misalignment. Also, if seizure does result, the babbitt usually melts and does not damage the shaft.

Aluminum alloys are intermediate between the babbitts and the bronzes. They have some of the tolerance for imperfect conditions of the babbitts combined with some of the load-capacity characteristics of the bronzes. These alloys are relatively soft, but have a greater tendency to weld to steel under unfavorable conditions of heat, pressure and contact than do the babbitts. Consequently, shaft surface conditions are more critical than for the lower melting alloys. Hardened shafts and good shaft finishes are definitely recommended for these alloys.

Copper-lead alloys are very similar to aluminum with respect to tolerance of shaft conditions. Copper has a high tendency to seize but the presence of the lead in these alloys offsets this.

The bronzes, consisting of copper and tin with little or no lead present, have a sufficient tendency to seize that they cannot be used at high speeds and high loads regardless of the shaft finish. These alloys are usually restricted to high loads at low speeds or, if sufficient lead is present, to intermediate speeds. Silver alloys are in a similar class and are only used in high-load, high-speed aircraft applications by the use of lead alloy overlays deposited over the silver.

The characteristics of the bearing materials are sufficiently different that the selection of a material is fundamentally based on load and speed, or on surface properties versus load capacity. A critical condition can exist for a high-speed babbitt application just as readily as for a high-load bronze application. A babbitt turbine-bearing failure at 50,000 rpm is just as serious as a bronze cable-drum bushing failure at 10,000 psi. In either of these extremes shaft finish can be a factor.

Summary: What can be done if shaft finish is

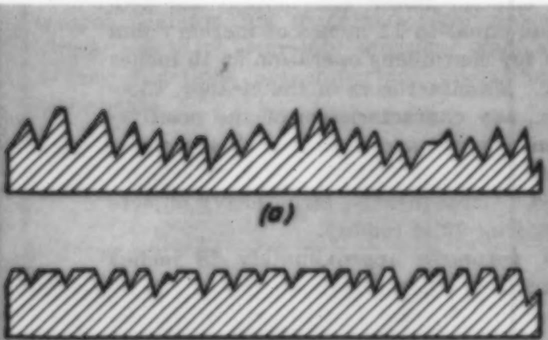

Fig. 5—Grinding or lapping of the rough surface, *a*, to remove the peaks produces a very desirable wearing surface, *b*. Measurements of the surface produced may show high roughness, but supporting surface area is large and oil-retaining "valleys" are present

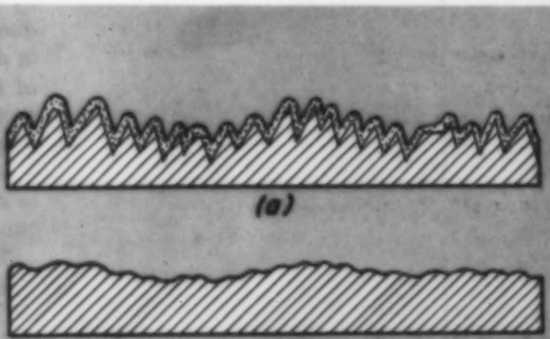

Fig. 6—Effects of plating, phosphating or oxidizing, *a*, and vapor blasting or electropolishing, *b*, are to remove or round off the sharp points on a shaft surface. Bearing area and life are, therefore, increased

a factor? The pat answer is to use a hard shaft and the best possible commercial finish. This is a good answer, but it may not be the whole story.

Hard shafts are fundamentally used to resist wear. It is much better for the replaceable bearing to wear than for the shaft to wear. It is also better for dirt to become embedded in the bearing than to partially embed in the shaft. A soft shaft that is exposed to dirt will not only wear, but will promote failure through friction. In the absence of these factors it is generally assumed that a hard shaft will resist seizure. This is apparently true, but perhaps only because a hard shaft is not roughened as much as a soft shaft during grinding. In other words, the cut of the grinding wheel produces shallower scratches on a hard shaft than a soft shaft.

One approach to this problem is to consider finishing methods that tend to round off sharp surfaces even if they be microscopic. Vapor blasting has been used. Other possibilities are electropolishing and periodic reverse plating. Electrochemical methods are available that have a leveling action on metal surfaces. The remaining problem is to apply such methods so that a desirable finish can be obtained at the desired finish size.

More information on shaft finish and the effect of the finish is required. In the absence of such evidence it can be assumed that finishing techniques constitute an important unknown factor.

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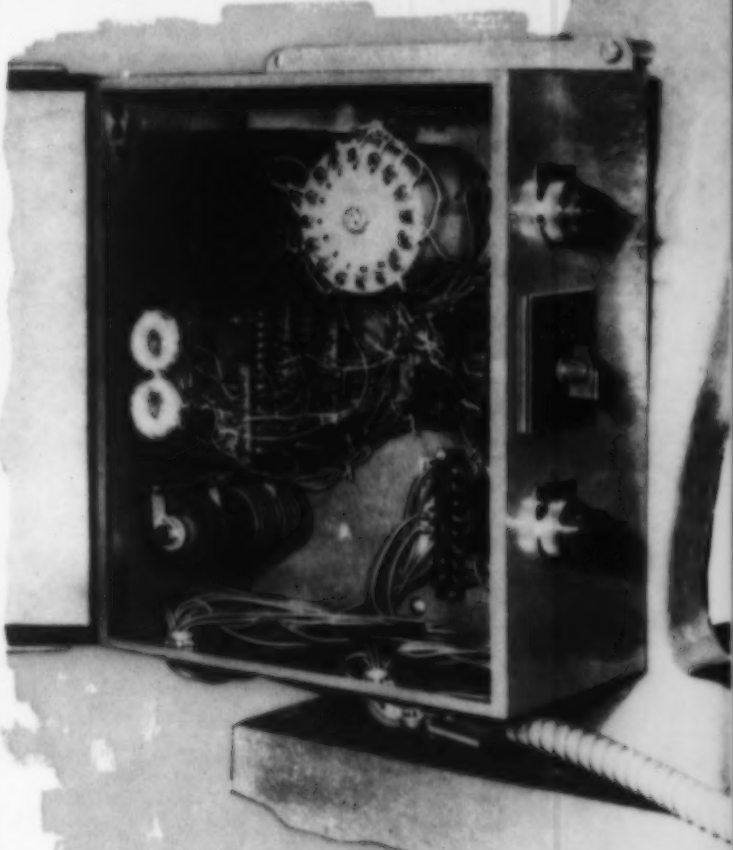
CONTEMPORARY DESIGN

Roots Blower Used In Industrial Vacuum Cleaner

A ROOTS-TYPE blower is used in a new high-vacuum, industrial cleaner. Driven by a 3-hp electric motor, the blower will produce vacuum equal to 12 inches of mercury and is designed for continuous operation at 10 inches of mercury. Manufacturers of the cleaner, Electroflow Inc., say characteristics of the positive-displacement blower are ideal for this application since air velocity increases when the nozzle is restricted. Consequently, large heavy objects can be picked up quite readily.

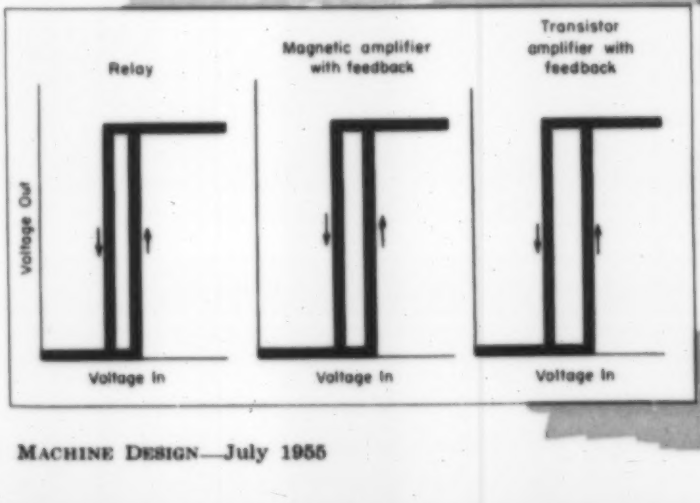
The unit measures approximately 18 inches wide, 36 inches high and 42 inches long. Models are available for permanent installation as well as mounted on casters. Another variation, for use in hazardous locations, is fitted with an air motor and nonsparking bronze blower impellers.

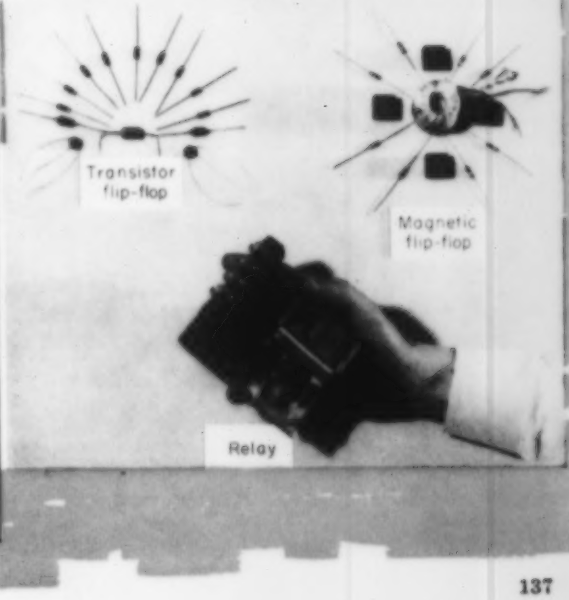
scanning the field for Ideas



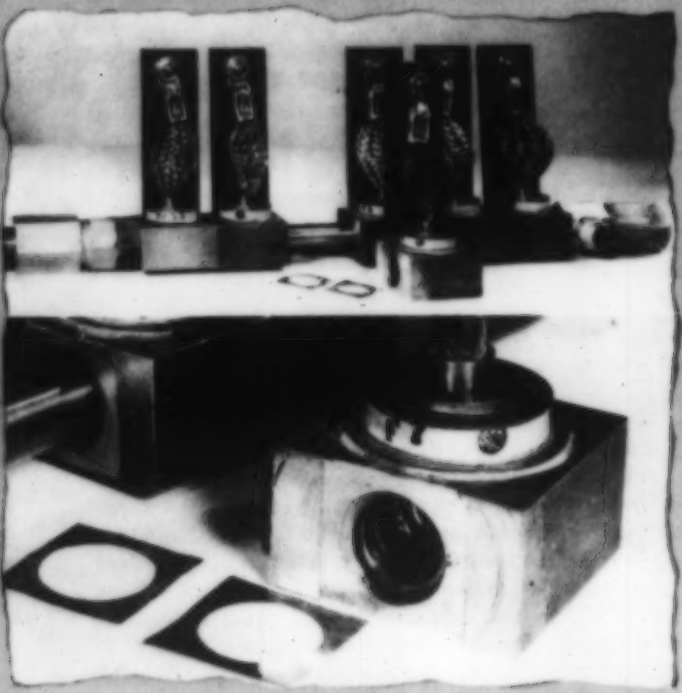
Static switching circuits offer a new concept in the design of electrical control systems. Developed by Westinghouse Electric Corp., Cypak systems employ magnetic amplifiers or transistors in special circuit combinations to perform switching functions equivalent to those of conventional relay systems. High reliability and flexibility in application are achieved through the design which eliminates moving parts and can be readily adapted to the control of machinery and processes.

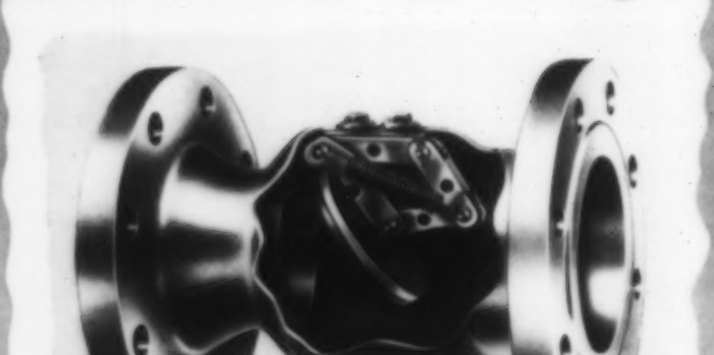
Basic elements of the Cypak systems are wound magnetic cores, transistors, selenium or silicon diodes, and resistors. These elements are combined in special circuit arrangements to provide different individual switching functions. Complete control systems are developed in building-block fashion by combining the various types of basic switching units to achieve the required degree of control versatility. Because of the special circuitry requirements, basic units of these systems cannot be interchanged one-for-one with relays. Instead, present practice permits interchange or replacement only on a system-for-system basis. Successful applications include both automatic and semiautomatic control systems for machinery and processes where repetitive starting, stopping and interlocking functions are important operating requirements.



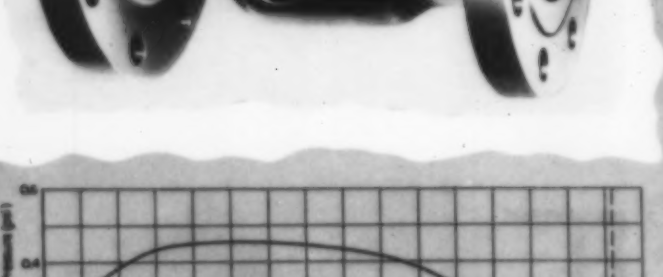


FLUID-TIGHT ELECTRICAL JOINTS are obtained with a construction employing gaskets made of pure tin foil. The foil is inserted between copper blocks wherever a combination electrical and hydrostatic joint is required. Developed at the University of California Radiation Laboratory, the design provides a sealed mechanical connection of low electrical resistance capable of holding water at a pressure of 300 psi. Although satisfactory results can be obtained with smooth contact faces on the blocks, a more effective joint which requires less clamping pressure can be achieved if one of the block faces is serrated with circular grooves. Typical practice has been to use 60-degree V-grooves, 0.012-inch deep, spaced 0.025-inch apart. Test results have indicated that for a foil thickness of 0.005-inch, average electrical resistance at the joint will be about 3 micro-ohms.



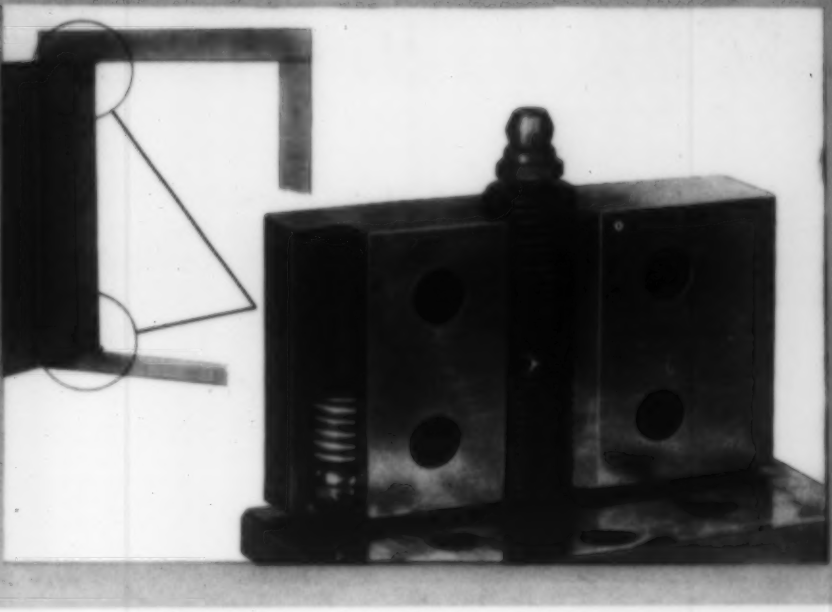


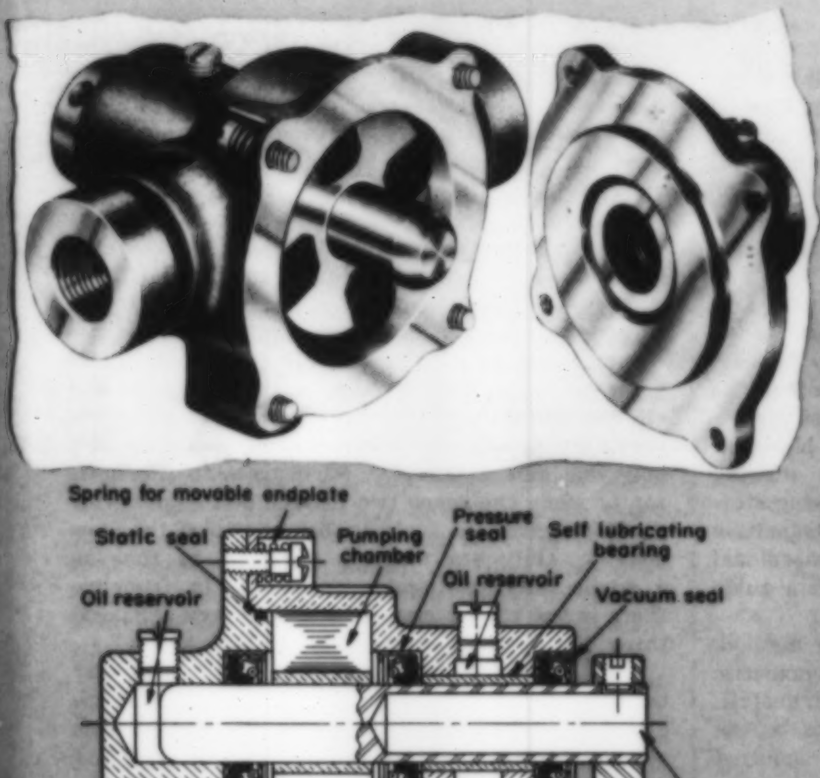
NOISELESS FLOW CONTROL in a check valve for piping applications is assured by a novel actuating mechanism based on four-bar linkage principles. The construction developed by W. R. Ames Co. utilizes a "knuckle" action, with two springs acting at the joint of the knuckle, to regulate the operation of a swing-type flapper during opening and closing. When the flapper is closed, mechanical advantage of the knuckle linkage multiplies the spring pressure to provide a positive seating action. This same characteristic also acts to close the valve just before reverse flow starts, thus eliminating the possibility of hammering or chattering. As the flapper swings open, the knuckle action reverses and the closing force decreases as the opening increases to provide minimum resistance under maximum flow conditions. Modification of spring characteristics permits variation of linkage forces to meet operating requirements.

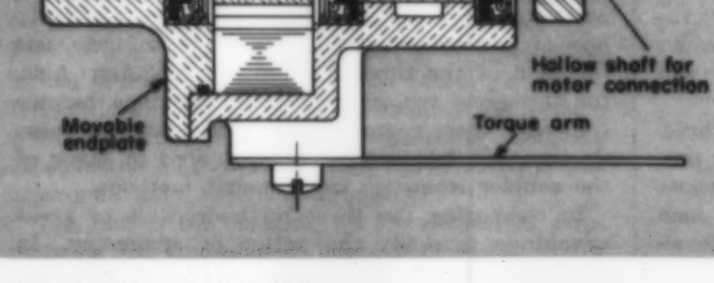


IDEAS

THREADED BEARING SURFACES simplify lubrication problems and eliminate endplay in pivot-mounted panel assemblies. Employed in a pressure-lubricated hinge developed by Betts Machine Co., the threaded contact surfaces act to harbor grease during operation and provide a sturdy pivot-bearing construction with high axial load capacity.

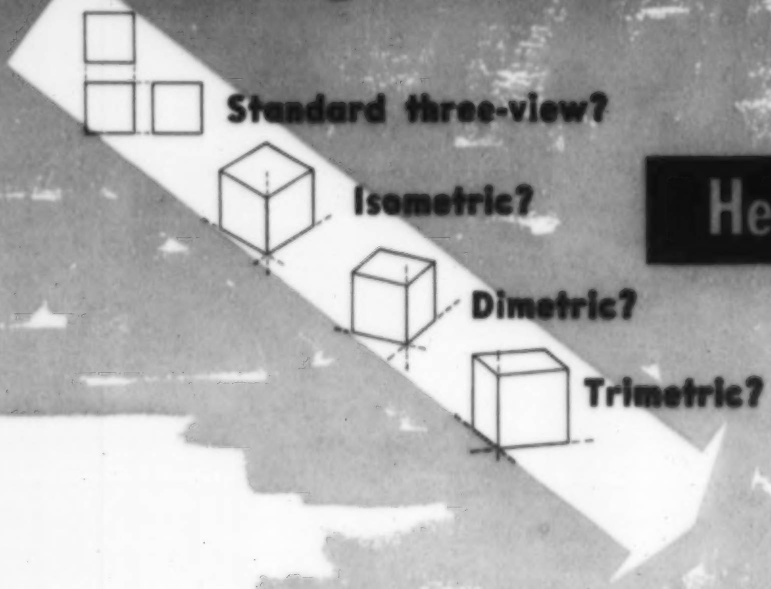





Spring for movable endplate
Static seal
Pumping chamber
Pressure seal
Self lubricating bearing
Oil reservoir
Oil reservoir
Vacuum seal
Hollow shaft for motor connection
Movable endplate
Torque arm

EXPANDING PRESSURE CHAMBER in a roller-vane pump designed by Hypro Engineering Inc. automatically compensates for fluctuating input conditions to maintain a constant-volume flow rate. When the pressure in the pump reaches a predetermined level, a spring-loaded end plate moves outward, increasing the volume of the pumping chamber and the clearances between the rotor and end plate. This expanding action permits the working fluid to recirculate, reducing maximum output pressure. To maintain constant flow, the pump can and may vary in pressure from 3 to 75 psi. When pressures drop, the end plate moves inward under spring action to reduce operating clearances. Leakage is prevented by means of an O-ring seal which is groove-mounted to the inner projecting "piston" section of the end plate.

Which Drawing Method?



Here's the case for

SIMULATED perspective (axonometric) drawing is as precise and legitimate a method of mechanical drawing as the standard orthographic method with plan, front and end views. In the last decade, simulated perspective drawing has, with the development of suitable equipment, made tremendous strides toward ever-increasing use in engineering.

Since three-dimensional or one-view illustrations are entirely to scale, they serve every purpose the standard drawing would. Additionally, they have advantages: (1) complete clarity about otherwise obscured features, (2) elimination of misinterpretation by people not trained as expert blueprint readers, plus (3) enormous savings in drawing time, sheet size and, consequently, in drawing storage space and reproduction cost. As a transition measure, many companies add a three-dimensional view to regular three-view illustrations as a guide for proper interpretation.

Isometric drawing, the most popular method, is only one member of the family of axonometric projections. The others are dimetric and trimetric. Because isometric has been considered to be the simplest of the three methods, it has acquired greater popularity and recognition. However, the apparent simplicity of isometric entails serious drawbacks which in dimetric and trimetric are not existent, or only to a lesser degree.

As a matter of fact, all three styles of three-dimensional drawing are simple in execution provided the draftsman has at his disposal the proper equipment for the particular style. Since such specialized drawing instruments have been developed only in the past few years, draftsmen may have preferred isometric since for part of the work the standard 30/60-degree triangles can be used as a substitute, although with limited efficiency.

Which Three-Dimensional Method?: If the three alternatives are compared, in isometric the three main axes (equivalent to and parallel with the three edges of a cube extending from one of its corners) are as a rule oriented at 90 and 30 degrees to the horizontal edge of the T-square, and all dimensions parallel with these three axes are shown at the same scale. In dimetric and trimetric, only one axis extends at 90 degrees to the horizontal while the other two include odd angles with it. In dimetric one scale applies to two of the axes equally. Only one scale is different, so that as a whole only two scales are used. In trimetric there is one characteristic scale for every axis, and three different scales must be used.

Right here is one of the major reasons why trimetric is usually avoided. Since scales and angles are all different, such practical drawing tools as ellipse templates would become very unwieldy and expensive. Three different ellipses would be needed to represent the same diameter circle, one for each of the three main drawing planes. Also, for the same reasons, trimetric drawings become somewhat more complicated and confusing to draw. So trimetric has largely been ignored in favor of the simpler isometric and dimetric methods.

In comparing the three methods, it is of great advantage to apply the notion of symmetry. In

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DIMETRIC DRAWINGS

and an analysis of advantages and disadvantages of each method

trimetric there is no symmetry because all angles representing 90 degrees, and all scales, are different from each other. In dimetric, symmetry exists only between the two axes with equal scales, the third dimetric axis being also the axis of symmetry. Isometric, however, is symmetric in all directions with respect to its axes, all angles and scales being equal to each other. Symmetry, however, can be a disadvantage in three-dimensional drawing, particularly if the object is symmetrical.

For comparison, one object in various positions, *Figs.* 1 and 2, are sketched in isometric and dimetric, respectively.

Part of *Fig.* 1 is the characteristic illustration of a cube, all edges of equal length, three edges being marked as axes *x*, *y* and *z*, and the three planes or faces called *xy*, *yz* and *xz* being of identical shape. Also, included are diagrams each showing one pair of adjoining edges in various positions, with the axis of symmetry shown as a dotted line.

As an analogy, in *Fig.* 2 a cube is shown in dimetric. The edges in direction of axis *x* are shorter than, or at a smaller scale than, those in direction of axes *y* and *z*, which are equal to each other. The angles representing the 90-degree corners on the *yz* face are different from those used in the other two faces which are therefore of different shape and size, although equal to each other. Additional diagrams illustrate the same selections of edges as in *Fig.* 1, but only three of the eight selections have axes of symmetry.

The reason for bringing up the subject of symmetry is the fact that, in mechanical design, edges

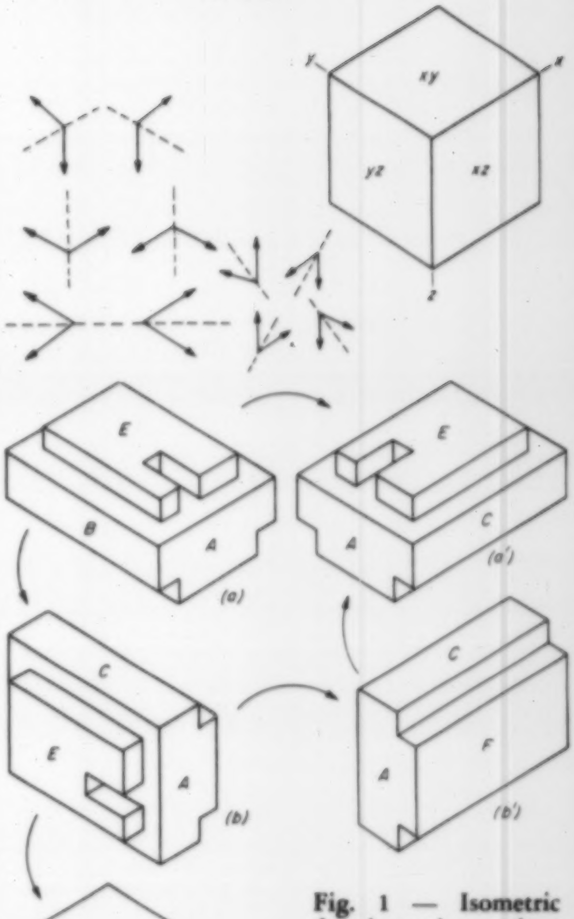


Fig. 1 — Isometric drawings in various positions; also typical axes of symmetry and conventional cube representation. Notice how some lines "blend" together

emanating from one point in 90-degree directions to each other are frequently equal in length. This is symmetry in reference to the point or to the bisector of the 90-degree angle. *Figs.* 1 and 2 show how a symmetric condition of the three-dimensional drawing impairs the clarity of the illustration of a symmetric feature.

It may be quite useful, before examining *Figs.* 1 and 2 further, to look at *Figs.* 3 and 4, which show extreme cases of triple symmetry in an object. These demonstrate with striking clarity the differences between isometric and dimetric. The object is a triple cross with all arms equal to each other. In regular orthographic, all three views would obviously look identical and would cause quite some thinking before a viewer would recognize and visualize the actual shape of the item. In *Fig.* 3 the cross is shown in isometric. The outside edges all blend into one another so that the whole picture is a cluster of lines, a far cry from what one would expect from a "quasiperspective" drawing. By heavy shading, the appearance may be enhanced, yet the result remains unsatisfactory.

Fig. 4 is a dimetric drawing of the same object. There is no need to emphasize its superiority in three-dimensional effect and clarity. The drawing speaks for itself. From this example, a conclusion may be drawn: an object which is symmetric in one, two or three directions should not be represented by a three-dimensional drawing method which is by its nature symmetric in the same way.

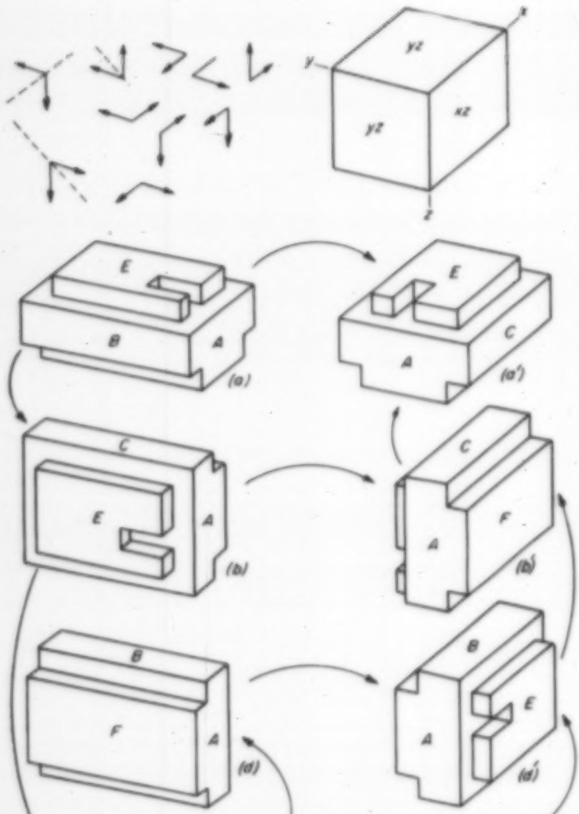
Selecting the View: *Figs.* 1 and 2, the object is a block with projecting portions and recesses. In both figures, positions *b* and *c* are obtained by revolving the block vertically from position *a*. In *Fig.* 2 a position *d* is added which is not needed in *Fig.* 1, as explained later. With one exception in *Fig.* 1, all the positions in the left vertical column have been rotated horizontally to the right, resulting in the positions *a′*, *b′*, *c′*, and d′, respectively.

The block has six faces, marked *A, B, C, D, E,* and *F* so that it is easy to recognize the positions and what information they furnish.

In the various pictures, *b′* and *c* in *Fig.* 1, and *d* in *Fig.* 2 should be discarded because they hide the projection with face *E* entirely. In isometric *Fig.* 1 the remaining positions *a, a′* and *b* are not too satisfactory either because outside edges as well, as some edges of the recess in face *E,* blend into each other as in *Fig.* 3. This is due to symmetrical features of the block, since the projecting portion on face *E* is exactly as high above the main surface of the block as its edges are set back from those of the block, and since the recess in face *E* is equally wide and deep.

In the dimetric drawings in *Fig.* 2, the undesirable blending of edge lines is greatly reduced, and entirely eliminated in position *b*. It could not be eliminated entirely in all positions because there is a certain amount of symmetry in dimetric as shown in the small diagrams at the top of *Fig.* 2. To eliminate blending of lines in cases of symmetrical objects, trimetric would have to be used.

Fig. 2—Dimetric drawings of the same object as in *Fig.* 1. Compare blending of lines with *Fig.* 1



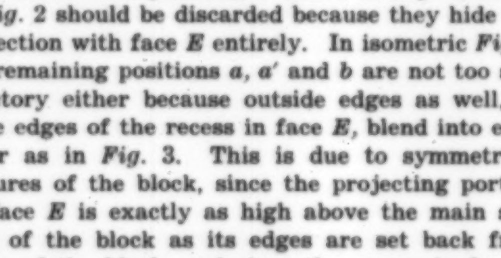


Fig. 3—Isometric drawing of a symmetrical object. Even with shading, the object could be a large cube with three smaller cubical projections, or a triple cross with equal arms

In general, dimetric pictures are more pleasant and "life-like." However, there are also other points in favor of dimetric. Because of the complete symmetry of isometric, the swing through 90 degrees horizontally, as from position *a* to *a′*, does not yield a different picture. One is the mirrored reflection of the other, except in case *b* to *b′*. Rotating *c* would only furnish a mirrored picture.

On the other hand, ***Fig.*** 2 shows that in every case the rotation to the right yields a different picture from that in the left column. The reason is that this type of dimetric has no symmetry between left and right. Therefore, the draftsman is free to choose the most favorable position for his purpose, depending upon which face of the object shows the greatest number of details, or where a great number of dimensions must be placed in the available area. In other words, since greater foreshortening occurs along axis *x*, a position should be chosen so the face which can be foreshortened most without causing lack of clarity extends in direction *x*.

Another reason for choosing between the left-hand and the right-hand positions in dimetric may be the desire to save space, or to prevent unsightly appearance in case the object is rather long in one direction. To illustrate this point, compare ***Figs.*** 5 and 6. ***Fig.*** 5 is isometric. If swung to the left, the picture would be exactly the same, mirrored, with no additional information furnished. In ***Fig.*** 6 the right-hand position has been chosen. Therefore, the face of the flange is emphasized and "spread," while the long tubular member with rather few details to show, is shortened. If in dimetric the object were swung to the left, the length of the tubular member would be exactly the same as in isometric ***Fig.*** 5, but the flange face would be very much condensed, much more than in isometric ***Fig.*** 5.

Dimetric offers a flexibility of presentation which is not obtainable from isometric. Also, it is more economical as it permits to arrange a maximum of illustration on a sheet of given size by placing those elements of the object that are of comparatively great length, in the direction of greater foreshortening.

For obvious reasons, it has not been possible to incorporate in ***Figs.*** 1 and 2 each and every position of the object theoretically possible. Omitted are all those in which faces *B, C, E* and *F* would extend vertically. However, if the page is turned so that the edges which extend at 90 degrees to face *A* are vertical, the other positions are shown exactly. Furthermore, both ***Figs.*** 1 and 2 show the object with face *A* in front, face *D* not being shown anywhere. However, it should be reasonably obvious, on the basis of the positions shown, how the reversed positions with *D* in front would appear. Unless *D* contains details different from face *A*, such showing of *D* would not be needed.

One-View vs Three-View Drawings: In general, every isometric or dimetric one-view drawing shows three faces of the object, in the same way that regular orthographic drawings show these three faces in three different views. In the majority of cases these views are sufficient. If, due to the complexity of the object, more than three faces must be shown for full description of the part, then in any case two views will suffice in axonometric drawing while in the regular system more than three are required—actually six if all faces must be represented. For instance, from the examples of ***Fig.*** 2, the position *b* and a reverse position of *d* would satisfy every demand, since the former would show faces *A*, *C* and *E*, while the latter would furnish *D*, *B* and *F*.

A look at ***Fig.*** 7 may emphasize some weaknesses in regular orthographic drawing in certain not too rare cases. The flange of ***Figs.*** 5 and 6 is illustrated in three views orthographically. In ***Fig.*** 7*a* some difficulty exists for the not-too-experienced

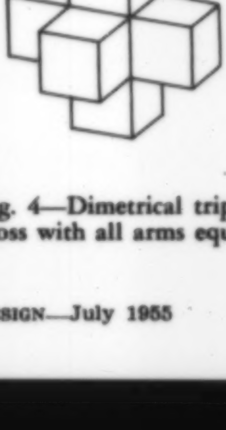


Fig. 4—Dimetrical triple cross with all arms equal

Fig. 5—Long part drawn by isometric method. Compare with *Fig.* 6

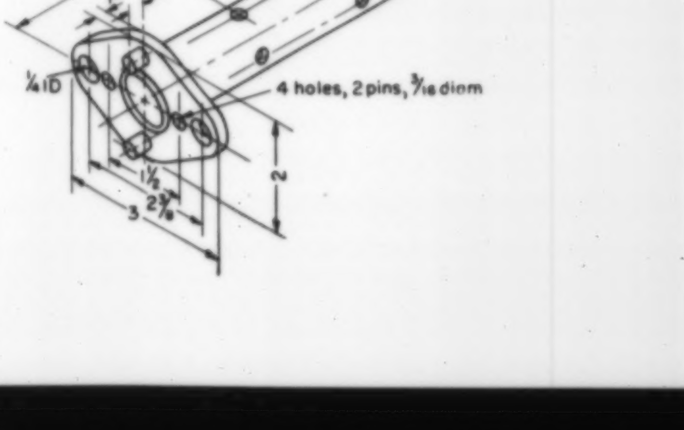
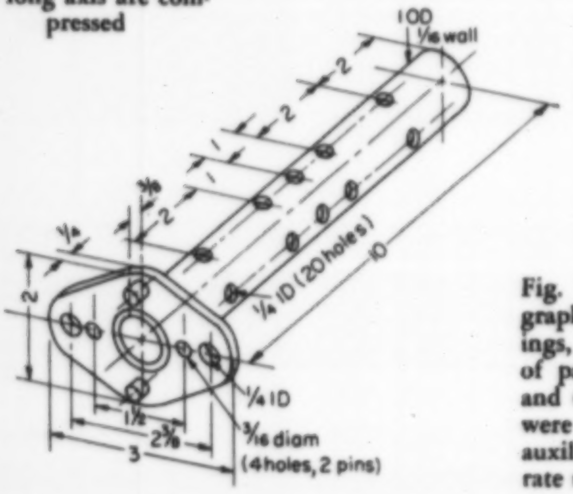


Fig. 6—Dimetric drawing of part in *Fig.* 5. Notice how crowded dimensions on the flange face are "spread out" compared with *Fig.* 5, and how spread-out dimensions on the long axis are compressed



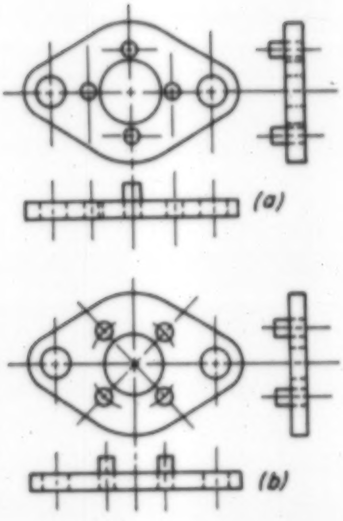


Fig. 7—Standard orthographic three-view drawings, *a*, of the flange face of part shown in *Figs.* 5 and 6. If pins and holes were located as in *b*, an auxiliary view or separate note would be needed

blueprint reader to visualize how many pins or studs are in the assembly, since one view shows only one, the other view shows two, and in the plan view nobody can see which circle means a hole and which a pin. Were the small holes and pins arranged as in *Fig.* 7*b*, certainly noone could tell where the two pins are inserted unless sections are made or additional information added. Three-dimensional pictures make the situation clear beyond a trace of doubt to even an entirely uninitiated man.

Equipment for Dimetric Drawing: A complete selection of equipment for dimetric drawings is available. Dimetric graph sheets for sketching make dimetric sketching as easy as isometric sketching, since all scales on the different axes are fixed in the odd-angle grid.

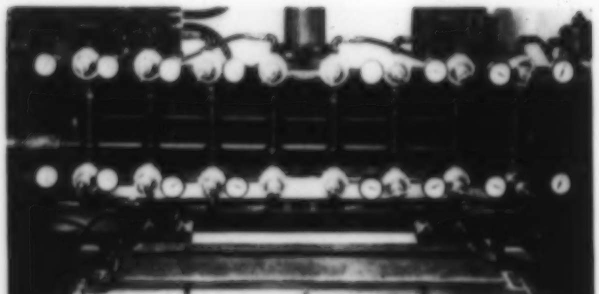
Ellipse stencils contain ellipses of proper shape and orientation up to 4½ inches in diameter. They also have drawing edges for lines in the direction of all three axes. For lines not parallel to the dimetric axes, 180-degree dimetric protractors can be used. Additional stencils are available for screw and bolt heads, and for helixes (threads and coil springs).

Silicone Belt Ends Vinyl Sticking

USE of a silicone-treated belt eliminates sticking of plastic to the heating element in a vinyl quilting press. Originally, the machine had to be shut down after each 800 yards of material to clean the base plate. Electronic Products Ltd. found the solution to the problem by making an endless paper belt impregnated with silicone.

Placed between the heaters and the vinyl, the belt sticks to the plastic just enough to keep it in register. It peels away freely after passing through the heaters. Each section of the belt is subject to only intermittent contact with the heaters and has ample time to cool off between applications. Processing of about 12,000 yards of vinyl is possible before the belt coating is renewed.

To make the endless paper belt, Kraft paper was impregnated with Silastic 131. Silastic 131 is a special silicone rubber stock that cures at temperatures low enough to permit application to organic materials.



Silicone-impregnated belt used to prevent vinyl sheet from sticking to the heater can be seen at the edges of the vinyl quilting

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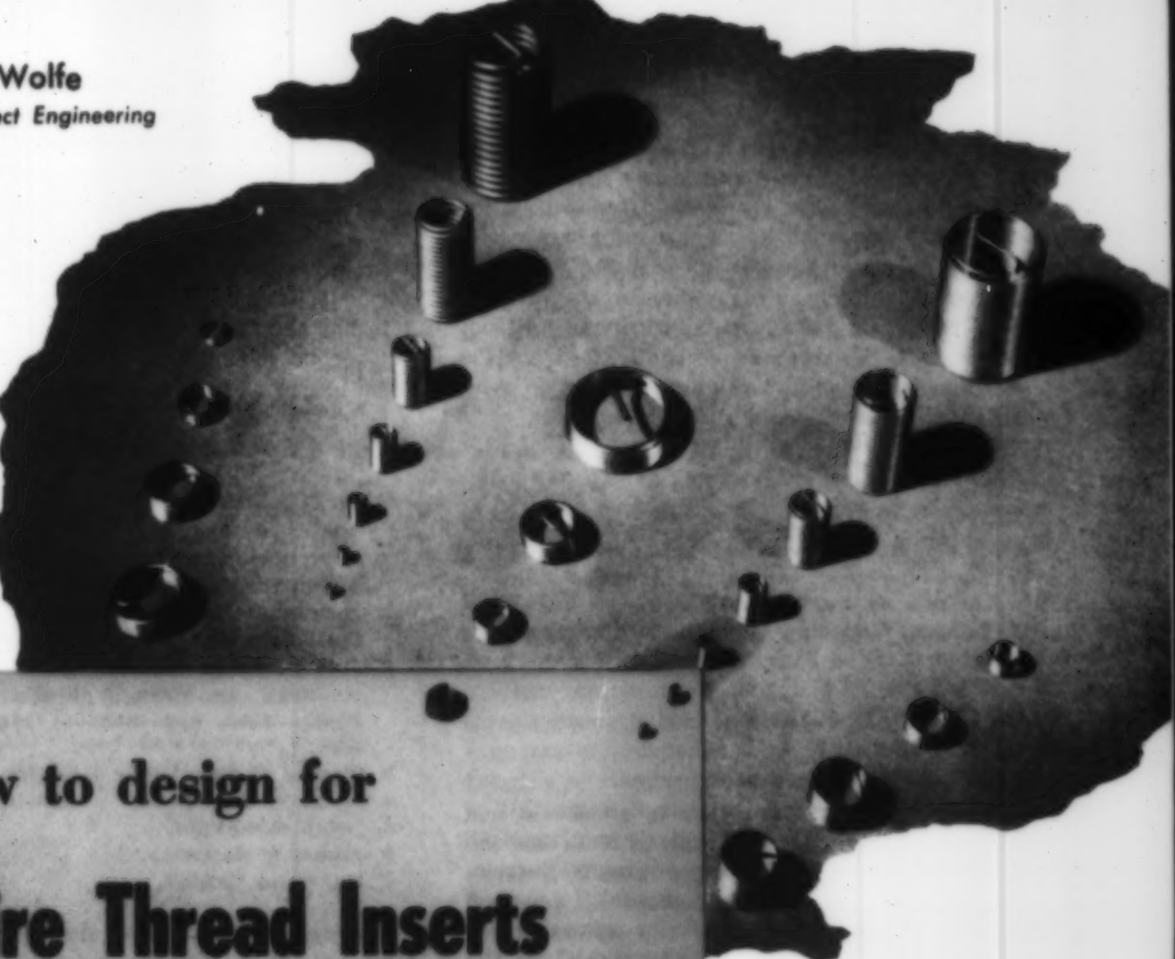


How to design for Wire Thread Inserts

Practical design factors for increasing thread strength and life

MANY desirable design configurations are often just beyond reach because they require a material with a combination of properties that does not exist. Extremes in light weight and high tensile strength are not usually obtained in a single material at reasonable cost. For example, threaded holes in light nonferrous metals, plastics or wood are frequently required to have strength not inherent in the base material. Therefore, in order to retain base materials originally selected for reasons other than thread strength, the application of thread inserts has today become widespread.

The wire thread insert, *Fig*. 1, is used extensively for protecting tapped threads in machine tools, aircraft, automobiles and in many other fields where thread fastenings are used. Produced in 18-8 stainless steel and phosphor bronze, wire thread inserts are helically wound coils of precision-formed diamond-shaped wires, *Fig*. 2, manufactured in standard lengths and thread sizes. As *Fig*. 1 shows, three

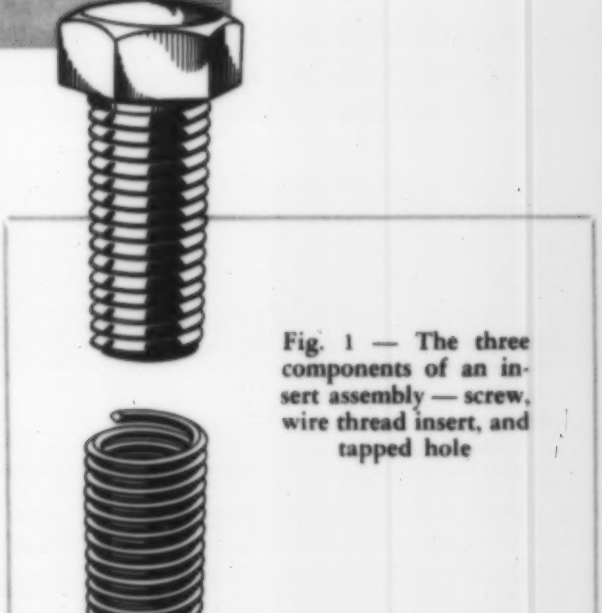


Fig. 1 — The three components of an insert assembly — screw, wire thread insert, and tapped hole

basic components of most insert assemblies are a cap screw, wire thread insert, and a tapped blind or through hole.

Each wire thread insert has a tang on the end of the first entering coil to serve as a driving member. The tang is left on the insert after installation except where it must be removed for cap screw clearance or product appearance. If the tangs are to be removed, notches are provided so they may be broken off cleanly after installation and will not interfere with the screw or stud. *Fig.* 2 shows the basic dimensions of a wire thread insert in relation to tapped threads and screw or stud.

Materials: In order of volume of use, the types of materials in which inserts are used are

1. Aluminum (cast, wrought and forged alloys)
2. Magnesium (cast, wrought and forged alloys)
3. Zinc-base die castings
4. Plastics (including fiber-glass impregnated materials)
5. Steel, cast iron
6. Copper, brass, bronze
7. Wood
8. Titanium

Wire thread inserts are used in aluminum and magnesium either to prevent thread wear and deterioration or to provide stronger threads. Deterioration of threads is usually caused by repeated disassembly and reassembly of cap screws or excessive vibration under loading. In such cases, the stronger threads provided by inserts are required where space restrictions do not allow sufficient thread engagement or the use of a larger screw size. Inserts are also used in nonmetallic materials such as plastics and wood for the same reasons.

Wire thread inserts are designed into steel primarily to resist corrosion, especially where elevated temperatures, salt water or acid conditions exist. With certain steel, aluminum and magnesium alloys, as well as titanium, removal of the cap screw from an unprotected hole, especially after operation under high loads at elevated temperatures, may result in an excessive galling condition. While studies now under way on plating and cyanide treatment may ultimately provide a surface-treatment answer to titanium galling, galling can be prevented by the use of wire thread inserts. They have proved useful at high temperatures or when titanium or steel bolts must be used in a titanium parent material.

Since the insert material is stainless steel, it has no inherent tendency to seize or gall when used with other metals. Moreover, the insert is roll-formed (not cut) and therefore presents a smooth internal thread surface which is important where the torque setting of screws to a high stress level must be consistently obtained.

Design Sequence: The successive points to be considered in design and specification with wire thread inserts are

1. Determine whether wire thread inserts can benefit the design due to use of one of the foregoing materials or because of product specifications or military requirements.
2. Determine cap screw and insert size and length according to strength characteristics, field service need, and standard practices of the user.
3. Class of fit (selected by designer)
4. Diameter dimensions.
5. Depth dimensions.
6. Assembly methods.
7. Protective finishes.

The designer must first decide on the basis of judgment, field service experience, research testing, or precaution whether or not he needs inserts. He must consider wear resistance, thread strength, appearance, corrosion resistance or elimination of seizing or galling. Often the decision is not left to him; inserts are required through specification by the potential user of the product, either commercial, industrial or military. For example, a typical military specification may require that "aluminum and other soft materials shall not be threaded for use as parts that are frequently disassembled." In referring to soft materials, *Handbook of Instruction for Aircraft Designers* requires that "The part shall be designed to permit machining and threading for the next standard screw thread or shall employ removable externally threaded inserts for the

Fig. 2—Proportions of the wire thread insert in relation to the standard screw and tapped hole

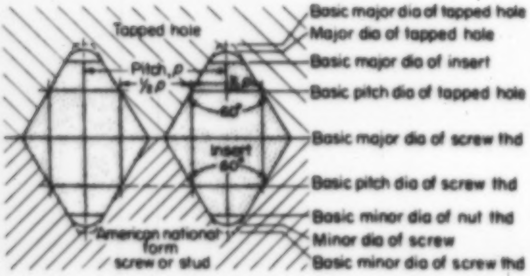

Tapped hole
Pitch, p
⅛ p
60°
Insert
60°
American national form
screw or stud
Basic major dia of tapped hole
Major dia of tapped hole
Basic major dia of insert
Basic pitch dia of tapped hole
Basic major dia of screw thd
Basic pitch dia of screw thd
Basic minor dia of nut thd
Minor dia of screw
Basic minor dia of screw thd

Table 1—Length of Engagement for Through Holes

Material	Ultimate Tensile strength (psi)	Length (diameters) Commercial Type Screws and Studs	Length (diameters) Aircraft Type Screws and Studs
Wrought aluminum	17,000	1½–2	2–2½
	30,000	1–1½	1½–2
	60,000	1	1–1½
Cast aluminum	20,000	1½–2	2–2½
	32,000	1–1½	1½–2
Cast magnesium	34,000	1–1½	1½–2
Forged magnesium	50,000	1	1½–2
Cast iron	.....	1	1–1½
Steel, steel forgings and steel castings	50,000 up	1	1–1½

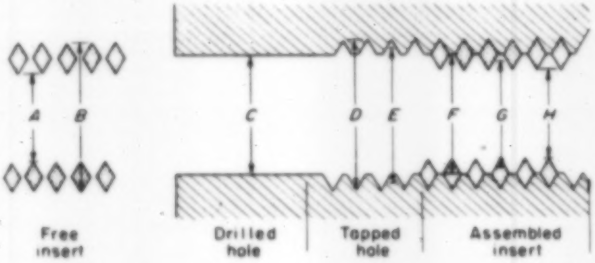
purpose of replacing the working threads."

Screw and Insert Size: When wire thread inserts are used in a new model or a slight design revision, the same screw sizes can be retained; shorter and smaller screws also may be feasible. When wire thread inserts are specified to prevent thread wear, they need not be considered at the initial stage of design in determining load capacity since the added thread strength provided by the insert is best considered as an additional safety factor. However, when inserts are specified for the purpose of providing stronger threads in critically loaded applications, the designer should either run tests on insert assemblies or obtain from the manufacturer test data on the strength of inserts. These readily available data cover a wide range of materials and thread sizes.

Table 2—Depth Dimensions

¼-28 Nominal Thread Size—Unified Fine	Insert Length in Nominal Diameters 1	1½	2	2½	3
Minimum drill depth, *S*, excluding point	0.411	0.536	0.661	0.786	0.911
Minimum tap depth, *T*, including 3½ threads chamfer of plug tap	0.375	0.500	0.625	0.750	0.875
Minimum full tapped thread length, *Q*	0.250	0.375	0.500	0.625	0.750
Maximum entering length, *R*, of screw if tang is not removed	0.214	0.339	0.464	0.589	0.714
Free number of insert coils (±¼ turn)	5	8½	11⅝	14½	17⅝

Fig. 3—Typical diameter data for a standard wire thread insert assembly



Diameter Dimensions

1/4-28 Nominal Thread Size
Unified Fine Thread Series (Class 3b)

		Min.	Max.
Free insert			
Inside diameter	*A*	0.233	0.257
Outside diameter	*B*	0.206	0.326
Drilled hole			
Minor diameter	*C*	0.257	0.264
Tapped hole			
Major diameter	*D*	0.2904	—
Pitch diameter	*E*	0.2732	0.2754
Insert assembly			
Major diameter	*F*	0.250	—
Pitch diameter	*G*	0.2268	0.2300
Minor diameter	*H*	0.2113	0.2190

LENGTH OF THREAD ENGAGEMENT: *Table* 1 gives recommended lengths of thread engagement when inserts are specified to prevent wear or deterioration of threads in either blind or through holes. The recommended lengths are listed in nominal screw diameters and are designed to develop the full strength of the screw. These lengths agree with conventional engineering practice and insure strip-proof threads even when sufficient wrench torque is applied to break the screw. Where tolerances on the thicknesses of attaching flanges are comparatively wide, inserts half a diameter longer than given in *Table* 1 are recommended to insure sufficient clearance. The table refers only to National and Unified Coarse and Fine Thread Series in metals. Applications in which wood, plastics and other materials contain insert assemblies are usually considered as individual cases.

When inserts are specified to provide additional thread strength, the length of the insert (or thread engagement) depends on loading requirements. Lengths of standard wire thread inserts are 1, 1½, 2, 2½ and 3 diameters. Of course, when the hole depth is severely limited, sufficient thread engagement may not be obtainable with the screw size desired. It may then be necessary to specify a larger screw size to obtain the desired strength.

BOSS DIAMETER OR EDGE DISTANCE: Conventional design practice in specifying boss diameter or edge distance can usually be applied because the increase in major diameter of the tapped hole in an insert assembly is very small. For example, in *Fig.* 3 major diameter *D* of the tapped hole for the ¼-28 cap screw is 0.2904-inch while a conventional tapped hole for the same screw size has a major diameter of 0.250 inch. Often edge distance from centerline of hole is considered equal to one nominal screw diameter, as though no wire thread inserts were being used. In the aircraft industry, the requirements for allowing space for the next larger cap screw size actually results in a large boss diameter if no inserts are used.

STANDARD INSERT SIZES: Wire thread inserts of 18-8 stainless steel (AMS-7245) or phosphor bronze (AMS-7247) are made in these standard sizes and thread classifications: (1) 4-40 to 1½-6 sizes in National and Unified Coarse Thread Series and (2) 6-40 to 1½-12 in the National and Unified Fine Thread Series. Other standard wire thread inserts sizes are made for automotive spark plugs, aviation spark plugs and pipe threads.

Class of Fit: Wire thread inserts meet the requirements of these classes of fits:

Class 2B. Most widely used for average mass production requirements.

Class 2 or 3B. For higher precision production needs.

Class 3. For highest precision fits compatible with interchangeability.

Increased acceptance of the Unifed Thread Sys-

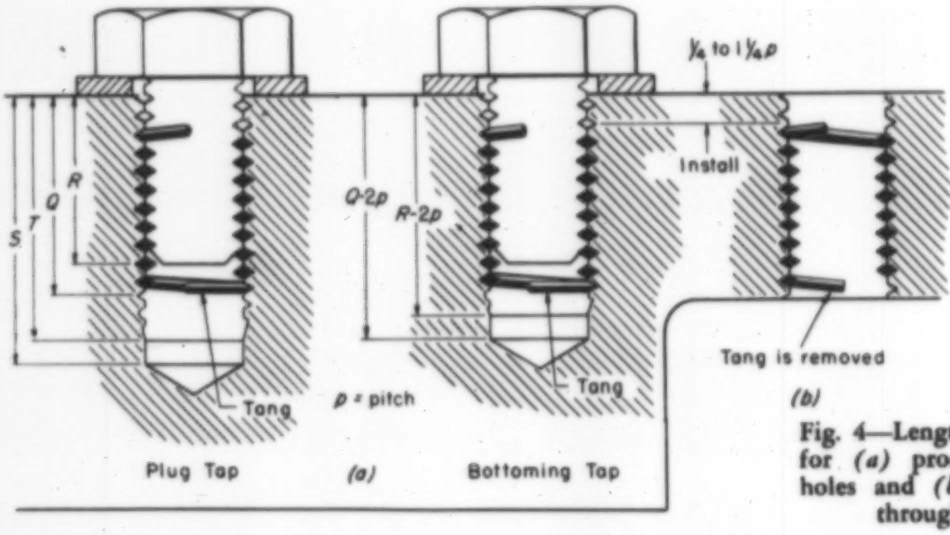


Fig. 4—Length proportions for *(a)* production blind holes and *(b)* production through holes

tem is indicated by the more frequent specification of Class 3B thread tolerances.

Diameter Dimensions: Dimensional data in both hole diameter and depth are available for all standard wire insert sizes. Representing the information available for each standard insert size, the data in *Fig.* 3 and *Table* 2 give the diameter and depth dimensions, respectively, for ¼-28 nominal thread size in the Unified Fine Thread Series (Class 3B).

Although such data as in *Fig.* 3 are given to help in specifying diameter dimensions, minor diameter *C* of the drilled hole and pitch diameter *E* of the tapped hole are the only diameter dimensions that need be indicated on a print. The inserts are designed so that when the dimensions of the drilled and tapped holes are maintained within the minimum values given, the dimensions of the insert assembly will match the screw size and class of fit selected. Minor diameter *C* of the drilled hole, for example, is specified to provide the amount of flank engagement required in conventional practice.

Depth Dimensions: Usually requiring more attention both in specification by the designer and in assembly of the inserts, depth dimensions for wire thread inserts are considered separately as applied to four types of threaded holes:

1. Production blind holes, plug style or bottoming style tap, *Fig.* 4*a*.
2. Production through holes, *Fig.* 4*b*.
3. Minimum blind holes, *Fig.* 5*a*.
4. Minimum through holes, *Fig.* 5*b*.

PRODUCTION BLIND AND THROUGH HOLES: The holes in *Fig.* 4 represent the most common condition in which there is sufficient depth of material to permit some leeway in locating the insert below the hole surface. Should there be strong reasons for exactly controlling the depth of the insert in the tapped hole, hand inserting tools may be used. However, greater efficiency in production results from the use of power-driven inserting tools if there is a wider allowable range for depth of installation. Nevertheless, some limit must be placed on the depth to which an insert is coiled into a threaded hole since it becomes wasteful to leave many threads on the screw that are not engaged with the insert. For the ¼-28 screw size *Table* 2 shows dimensions for installation of the insert in production blind holes and production through holes.

The drilled hole may be threaded with either a plug style tap or a bottoming style tap, *Fig.* 4. Because the plug style tap requires 3½ pitches of chamfer and the bottoming style tap requires only 1½ pitches of chamfer, the bottoming style tap requires two less pitches in drill and tap depth. The saving of two pitches in depth, however, is not critical unless the minimum blind hole, *Fig.* 5, must be achieved in designs where flange thickness is limited.

MINIMUM BLIND OR THROUGH HOLES: For minimum through holes, *Fig.* 5*b*, the wire thread inserts have been engineered so that standard increments of insert length based on nominal screw diameter can be used in a thickness equal to the nominal insert length. The ¼-28 wire thread insert in the example will fit properly into a ¼-inch thick part. Proper clearance is obtained because the assembled length of the insert is designed to be ½ pitch short of ¼ inch.

The much smaller range of installation depth (only ¼ pitch) for minimum holes requires more careful assembly of the insert, taking a longer time and involving greater production cost, but may be necessary for proper overall assembly in critical cases. *Fig.* 5*a*, of course, shows a bottoming tap in order to save the depth of two pitches.

COUNTERSINKS AND COUNTERBORES: If specified for either a through or blind hole, the maximum depths of a countersink or counterbore must be added to the minimum drill depth *S*, *Fig.* 4, and full tapped thread length *Q* to be certain that thread length is sufficient so that the top coil of the insert does not rest in the countersink. The

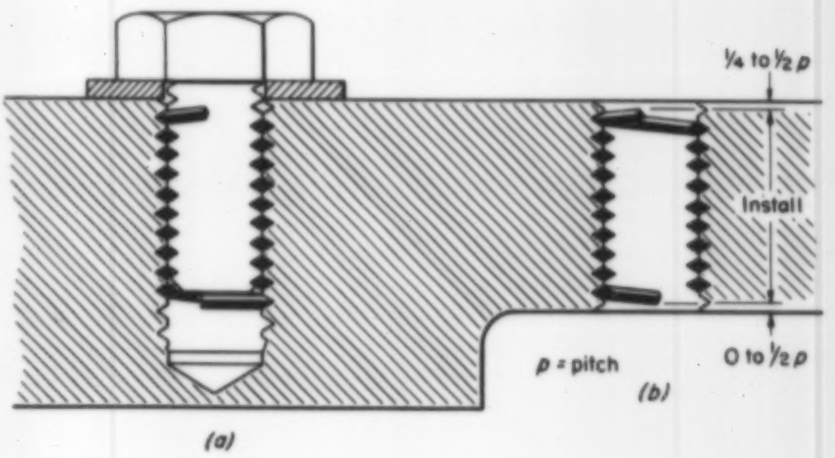
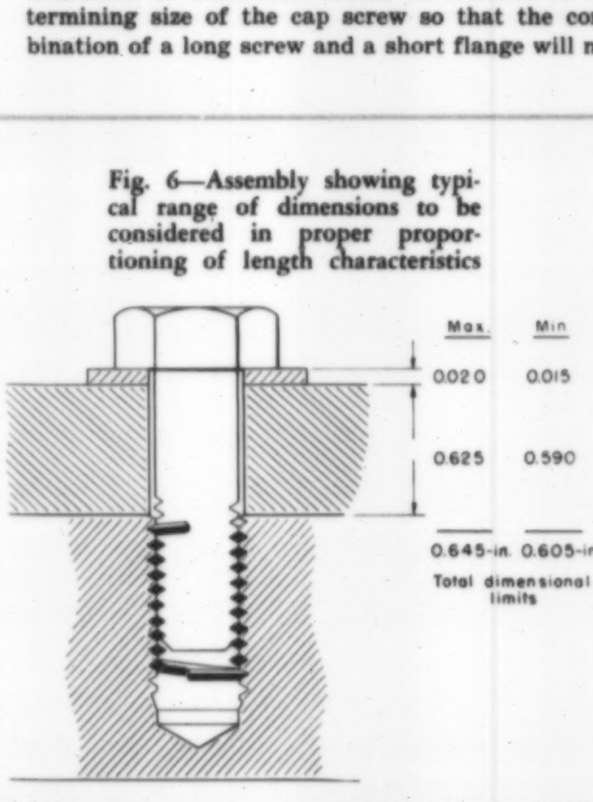


Fig. 5 — Length proportions for *(a)* minimum blind holes and *(b)* minimum through holes

countersink is usually specified as equal to the major diameter of the tap, +0.020, − 0 inch. The countersink should have a 120-degree included angle to facilitate assembly of the insert into the tapped hole. Thus, the 120-degree included angle matches the profile of the tapped threads and the insert is then permitted to slide down the surface of the countersink into the first threads during insertion.

THICKNESS VARIATION: In selecting the proper length of cap screw or bolt, the designer should consider the maximum and minimum dimensions of the attaching flanges and washers, lock nuts and wires. For example, in *Fig.* 6 both the washer and the flange have maximum and minimum thickness limits which must be considered. The minimum dimension of 0.605-inch should be checked in determining size of the cap screw so that the combination of a long screw and a short flange will not result in the screw striking the tang of the insert. The maximum flange thickness must be known in order to select a cap long enough to insure sufficient thread engagement with the insert.

Fig. 6—Assembly showing typical range of dimensions to be considered in proper proportioning of length characteristics



The tang is usually left on the insert in blind holes because greater bottom clearance is required to remove the tang, thus producing no advantage but only an extra step in assembly. Of course, the tang is always removed when an insert is applied in a through hole.

Assembly: A hand inserting tool is used for limited production or salvage, while a power tool is most economical for large production quantities. Special tools and technical information on assembly and removal of the tangs have been developed.

Finishes: How the part is finished may have an influence on production sequence and, hence, upon design.

MAGNESIUM: The three most common of the many available finishes used to protect magnesium alloys against corrosion are H.A.E., Iridite No. 15, and Dow No. 7.

When the H.A.E. finish is required, a polyethylene of phenolic stop-off plug should be used in the tapped holes to prevent build-up of the finish on the threads. Such build-up could make it difficult to maintain the desired class of fit.

Iridite No. 15 and Dow No. 7 finishes may be applied to the magnesium alloy either before or after the insert is installed, since there is no build-up on the threads with either of these finishes.

ALUMINUM: The three finishes most commonly used to protect aluminum materials are chromic or sulphuric acid method of anodizing, Alodine No. 1200, and Iridite No. 14 and 14-2.

The chromic acid method is most widely used throughout industry but there are several precautions to note. The first and most important is that there is a certain amount of build-up on the tapped threads if the holes are tapped before the anodizing process, especially at the bottom of a blind hole. This effect can be overcome by drilling and tapping after anodizing. Or, if drilling and tapping must be performed before surface treatment. rubber stop-off plugs may be specified to prevent build-up.

The Iridite No. 14 and 14-2 finishes can be applied either before or after installation of the insert and still meet military specifications for corrosion resistance. The Alodine 1200 finish may also be applied either before or after the insert is installed in the parent material because no build-up takes place on the threads. Of course, the ability to apply the protective finish after tapping and installing the insert may reduce handling cost.

The selection of the specific protective finish for either magnesium or aluminum depends on individual specifications and design requirements. In all cases, however, a liquid-type zinc chromate primer is recommended for application before the insert is assembled in the parent material.

For those applications where excessive corrosive conditions exist, the designer may specify that the top coil of an insert in a blind hole and the area surrounding it should be touched up after the insert is installed. The surrounding area, on both the top and the bottom surfaces of a through hole, should also be treated with the primer. When applied under controlled manufacturing conditions, the primer will not build-up enough on the tapped hole to cause a fit problem.

New Products and Developments in Rubber

RUBBER and rubber compounds are high on the list of widely used engineering materials. Applications of rubber range from tiny O-rings to mammoth tires. Some of the recently developed compounds and applications are presented here.

New Compounds: Uncured blends of a new type of styrene resin with any chloroprene rubber have been found to have good tensile strength, high stiffness, and heat distortion points of 190 F and above. An outstanding feature of these blends is their high impact strength in the uncured state. By varying the ratio of the styrene resin and the chloroprene rubber, or by varying the type of styrene resin used, a wide range of physical properties becomes possible. These stocks can be calendered, compression-molded, postformed or extruded.

Presently being field-tested is Adiprene B, a urethane type rubber stemming from the field of isocyanate chemistry. It is said to possess excellent abrasion resistance, high tensile strength, and resistance to oxygen and ozone degradation; however, it is difficult to process. Samples for industrial research will not be made available until further tests prove its theoretical value.

Filastic is a new type of rubber produced by breaking down raw natural rubber into fiber form and reconstituting it into a web-like formation in which the fibers are locked wherever they cross. The product is said to provide great porosity, elasticity, flexibility, and considerably greater strength than conventional foam rubber. A ¼-inch thick sheet is so porous that tobacco smoke can be blown through it almost as readily as through a sieve, yet is strong enough to be sewed or stapled at the edges and hold firmly.

Until the present time, over 150 fluoroethylene compounds have been introduced. Further developments of these compounds have led to a new Kel-F elastomer which is said to have an unusual combination of elastomeric properties, chemical resistance, and thermal stability. It is serviceable over a temperature range of −15 to 400 F and is unaffected by hydrocarbon fuels and lubricants, oxygen, ozone and sunlight. The elastomer is nonflammable, tough, abrasion and heat-resistant, and is easily processed. Possible applications include fuel hose, diaphragms, gaskets, seals, O-rings, tank linings and containers. At present, all available material is being used for military purposes.

New Applications: The Navy is putting rubber to a new use as the surface skin of submarines. The rubber panels provide a protective housing for the sonar electronic gear. The panels are constructed to withstand the same sea pressures and forces that must be resisted by the outer hulls of conventional submarines. Yet the specially developed rubber permits sound waves to pass through in about the same way sound travels through sea water to prevent blanking out or distortion of the sound signal.

Already traveling on the roads are busses and coaches with all four wheels suspended on rubber, and front wheels without a front axle. Torsilastic rubber springs give the busses "knee action" never before available in busses. The springs look like large steel pipes and consist of a metal shell and central shaft. The space between the shell and shaft is filled with rubber bonded to the metal. Either the shaft or the shell is held stationary while the other is partly rotated by a torque arm. All the springing is accomplished by the twisting movement in the rubber. A hydraulic system which operates on all four springs independently, maintains the same road clearance regardless of the load by winding or unwinding the springs as the load increases or decreases. The spring eliminates metal-on-metal vibration; there are no bearings to be lubricated or serviced, and no abrasion, rust, or wearing action from dirt, water or mud. The springs cannot develop squeaks or rattles.

Abstracted from a paper by Lillian Sutter and Leora E. Straka, presented at the ASME Annual Meeting, November-December, 1954.

Friction Fundamentals

- **Basic Concepts**
- **Design Factors**
- **Wear Rate**
- **Temperature Effects**

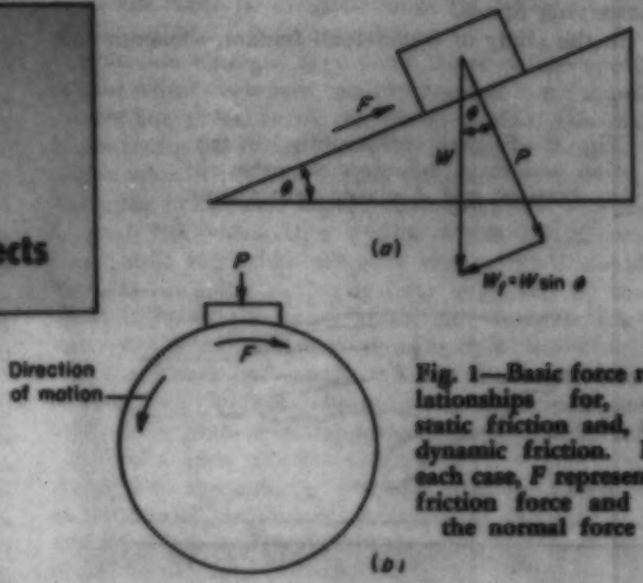


Fig. 1—Basic force relationships for, *a*, static friction and, *b*, dynamic friction. In each case, *F* represents friction force and *P* the normal force

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More than just a simple natural phenomenon, friction is an effect produced by the combined action of many forces and influences which vary with the conditions of application. Relative speeds of moving surfaces, contact pressures, surface temperature, material combination properties, etc., may all play an important role in design.

To aid design understanding of this fundamental concept, Machine Design will present a group of articles covering three important aspects of friction and its effects. This first article deals with the nature of friction. Related subjects to be treated in future months are friction materials, both metallic and nonmetallic, and the principal friction devices—clutches and brakes.

ALL OF THE effects of friction involve force. The same force which keeps stationary objects in place tends to retard objects in motion. Basic concepts of the two corresponding types of friction — static and dynamic — are depicted schematically in *Fig.* 1. The first is simply a tangential force associated with a normal force and no work is done as shown in *Fig.* 1*a* where a block is supported on an inclined plane by static friction. The second involves both force and speed, and energy is expended. *Fig.* 1*b* shows schematically a friction element on a rotating drum; mechanical energy is converted directly to heat at the rubbing surfaces by virtue of friction, giving the immediate effect of increasing the temperature of the rubbing materials.

Classical Approach: The coefficient of friction, μ, is classically defined as the tangent of the angle of repose of a body on a surface. The angle of repose, ϕ, is the maximum angle with the horizontal to which the plane surface may be inclined before the body slips down the inclined plane under the influence of gravity. In *Fig.* 1*a*, the coefficient of friction is:

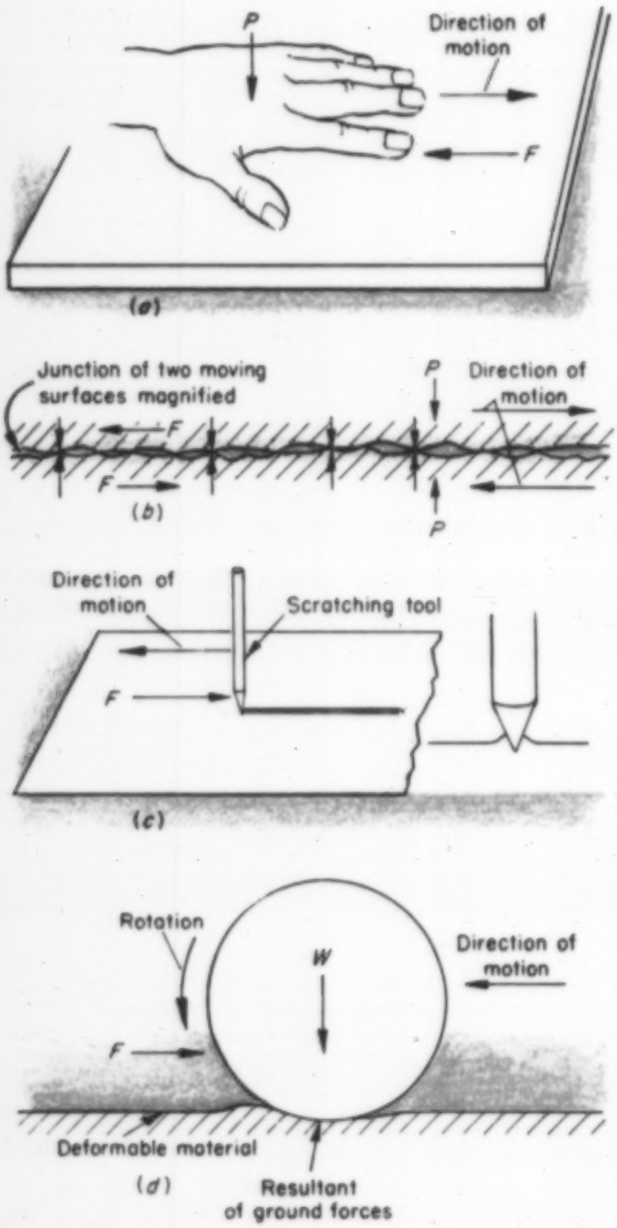
$$\mu = \frac{W_t}{P} = \frac{W \sin \phi}{W \cos \phi} = \tan \phi$$

where W_t is the tangential component and P the normal component of the weight, *W*, of the body.

While the classical laws for friction are often quoted and are of use in the study of friction theory, they have less significance in practice where heavy pressures are used at high speeds and temperatures. Although friction has been thought to be independent of area and speed, friction elements nevertheless exhibit coefficients of friction which vary with speed, pressure, and temperature. It is not sufficient to talk about the coefficient of friction of two rubbing surfaces as a single unvarying figure.

In the study of commercial friction elements and mechanisms, it is not possible to determine the coefficient of friction in the classical manner, nor does it have the same meaning as in the classical sense. Under dynamic friction conditions, 1*b*, the weight of the friction element is replaced by the pressure with which two surfaces are applied to each other. The inclined plane, which appears to be boundless in the classical analogy, is replaced by a drum in the automobile brake and an opposing disk in the clutch.

Fig. 2—Factors contributing to friction action: *a*, adhesion; *b*, cohesion; *c*, abrasion; and *d*, elastic deformation



Classically, the static breakaway friction is measured. From a practical standpoint, however, dynamic engagement and breakaway friction conditions are important in a clutch, while kinetic friction of slipping surfaces and static breakaway friction at rest are important in a brake. In the classical example there is no temperature problem; the temperature of the two rubbing surfaces is assumed to be the ambient temperature, and no heat is generated by the rubbing surfaces. But in practical application, the purpose of a friction element is to absorb energy. In fact, the energy to be absorbed in the friction mechanism of an airplane brake is often quite large.

In view of the discrepancy between the classical and practical interpretations of friction, it is necessary to re-evaluate the concepts. The phenomena observed by the early French physicist, Amontons, on the effect of pressure and by Coulomb on the effect of velocity were of scientific value but the friction element of today requires evaluation under much more severe conditions.

Mechanism of Friction: Several factors contribute to the phenomenon of friction. These are adhesion, cohesion, abrasion, and elastic deformation. The friction of adhesion is similar to that involving a fluid or a viscous mass. The friction of one's hand on glass or on a varnished table top, *Fig.* 2*a*, is high, but it is friction which increases with the time the hand is allowed to rest on the surface. Here, the pores of the skin adhere to the table top like suction cups, if a very small amount of moisture is present to complete the seal. The adhesion can be broken by spreading a little powder on the hand.

Cohesion, the second factor, is the phenomenon by which surfaces of compatible metals become welded together, *Fig.* 2*b*. Fusion welding causes cohesion over large areas, but the welding resulting from friction occurs over extremely small contact areas. Thus, metal may cohere with metal, but it is difficult to conceive of the coherence of cloth with metal. Nor is it generally conceivable that the resin in a molded brake lining will cohere with the metal brake drum, but resin will cohere with resin. Copper will cohere with copper, and iron or steel will cohere with the same. Most mutually soluble metals, in fact, will cohere.

The third factor contributing to friction is mechanical abrasion, *Fig.* 2*c*. It is the same effect as that required by a cutting tool which plows through an object, displacing or removing a quantity of metal. In such a manner, a diamond point embedded in a tough material and dragged across a soft surface will score the surface, leaving a trough from which material has been removed or a trench banked by displaced metal. This effect involves a measurable force, and even though the scratch may be minute, the sum of the forces necessary to make many scratches in a surface is considerable. Friction material manufacturers sometimes find it necessary to include in their composition small amounts of abrasive material which tend to mark the opposing surface and may contribute to the friction.

The fourth factor is the elastic and plastic deformation induced by a load moving over a surface, *Fig. 2d*. The friction force resulting from deformation is not very important in the case of two disks engaging each other. It is a well known fact that in the two-shoe internal-expanding brake there is a definite tendency for the brake drum to go out of round, becoming elliptical in shape during braking. The force necessary to maintain the ellipticity of the drum during rapid rotation is considerable, and contributes to the friction force.

Contributing Factors: With the realization that the modern friction mechanism is essentially an engine in which mechanical energy is converted to heat, it is well to survey the interrelation of friction and wear rate of the friction materials. There are several basic factors affecting friction and wear which must be analyzed and considered. The most important of these is pressure. Many of the organic or molded friction materials exhibit no change in friction with pressure, but some of the sintered-metal materials suffer a decrease in friction as the pressure on the lining increases, *Fig*. 3. The coefficient of friction of one material decreases from about 0.3 at 20-psi plate pressure to about 0.22 at 200 psi.

For metallic materials to have friction decreasing with increasing speed is common, *Fig*. 4. The effect of speed on friction is not limited to sintered metal, but is noticeably evident in the cast-iron railroad brake shoe where it is not only a fact that the average friction from a 100-mph stop is much less than from a 40-mph stop, but it is very desirable and necessary. In the case of the railroad wheel, *Fig*. 5, the curve of the retarding force of the brake should be parallel to the curve of the adhesion of the wheel to the rail. For railroad applications, adhesion is expressed as F_a/L where F_a is the force required to cause the wheel to slip on the rail and L is the wheel load.

Adhesion becomes very much lower as the speed of the wheel increases, mainly because high speed causes the pressure of the wheel against the rail to be increasingly variable. If, during a "bounce" of the wheel when the normal pressure is relatively light, the brake shoe should have sufficient friction to grab the wheel, then a slide which would continue until the brake pressure was released would be initiated. This action is fully explained by the great difference between static and dynamic friction of the metal brake shoe against the wheel, and the wheel against the rail. If the wheel is in rolling, not sliding, contact with the rail, the friction is high and the lower sliding friction of the brake shoe against the wheel may continue. As soon as the brake shoe is able to grab the wheel and force it into sliding contact with the rail, the system tends to remain in this condition until the brake is released. Therefore, it is advantageous to have the coefficient of friction of brake and wheel dropping with increased speed, as does the adhesion.

There is a parallel to this situation in the case of the automobile, but the treatment is different. Whereas the railroad brake is applied with a mechanical pressure which is not sensitive to the results obtained, automobile brakes are controlled by human beings who gage the pressure to be applied by its effects. If the tires lose their adhesion, the operator releases the brake pressure

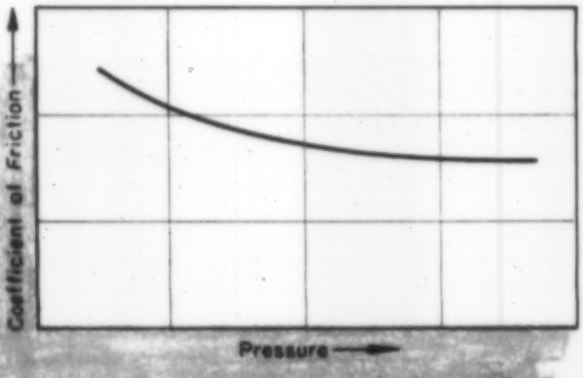


Fig. 3—Typical effect of pressure on coefficient of friction for sintered-metal friction materials. Organic or molded materials have a straight line characteristic

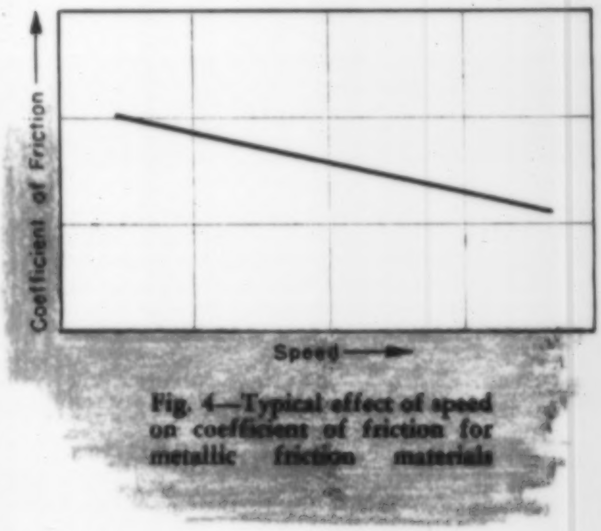


Fig. 4—Typical effect of speed on coefficient of friction for metallic friction materials

enough to restore the ground-to-tire adhesion and then increases the pressure to obtain the full effect of rolling braking.

Beyond the effects of speed and pressure, temperature seems to have an independent effect on the coefficient of friction. The magnitude of the effect of temperature varies with the material and may be greater than that of either pressure or speed. Thus, it is possible for one material to show a moderate increase in friction as temperature increases, while another may do just the reverse. To separate completely the effects of pressure and speed changes from the effects of temperature changes is probably impossible, because if pressure is constant and speed is increased, the surface temperature will increase. Similarly, if the speed is kept constant and the pressure is increased, there will be a corresponding increase in the amount of power, resulting in higher temperature.

Wear Rate: The subject of wear is a broad one, since it is affected by many complex interrelated factors. There appears, however, to be a very close relation between the wear of a particular material and the amount of work done in the braking or clutch application. Under conditions which are not extreme, the rate of wear of a constantly dragging friction element will increase in nearly a straight line with increasing speed. Similarly, the work done by a friction element dragging at a constant speed and variable pressure will increase in direct relation with pressure.

If, on the other hand, a braking stop is considered in which a vehicle of given weight is decelerated to rest from a given speed, the energy converted to heat during the stop varies with the

Fig. 5—Relation of friction forces acting on a railroad wheel during braking. For best results, the curve of the retarding force at the brake shoe should be parallel to the wheel-to-rail adhesion curve

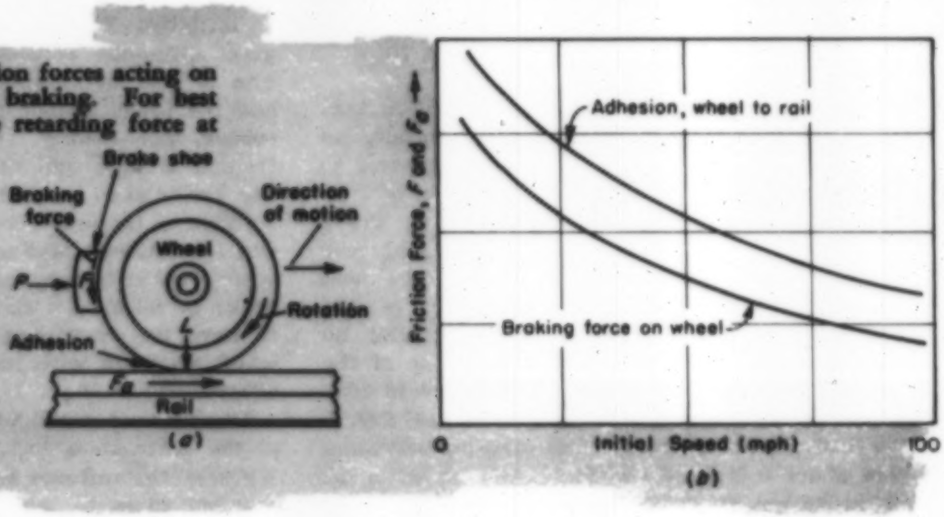
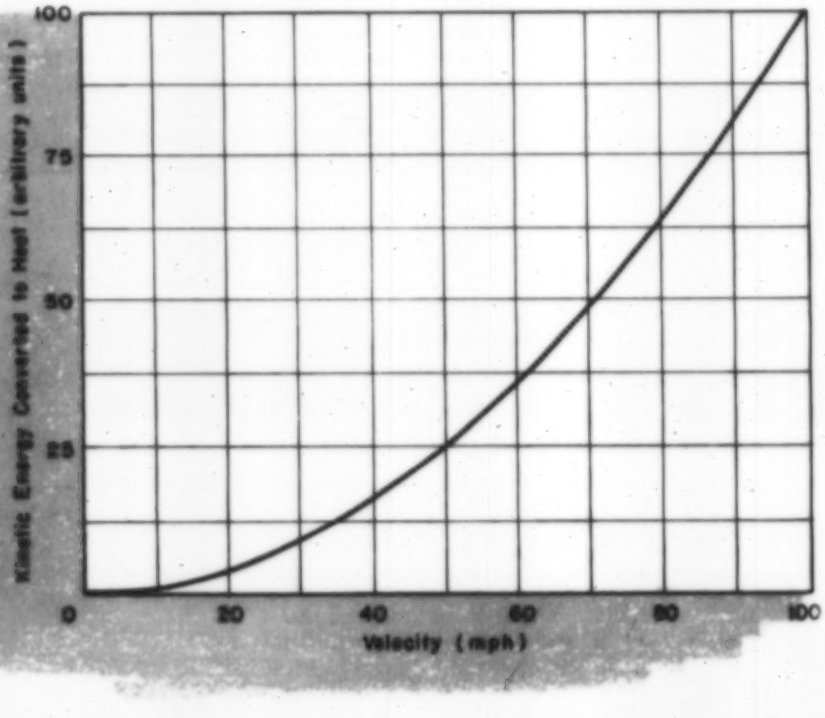


Fig. 6—Relation of kinetic energy, which must be absorbed during braking, to vehicle speed



square of the initial speed, *Fig.* 6. Thus, the energy, and the wear on friction elements, in a stop from 100 mph are four times as much as when the same vehicle is stopped from 50 mph. If, in the same example, the deceleration rate is increased by increasing the pressure, the energy of the stop remains the same, and the wear would at first be expected to be the same. Because energy is absorbed at a faster rate, however, the surface temperature will be higher and the wear for the stop will be greater.

Higher temperature of the rubbing surfaces causes higher wear rate. With organic materials such as paper, cloth, cork, and leather, the permissible temperature rise is limited by the possibility of chemical deterioration, which destroys the friction element. Resin-bonded, molded-asbestos friction elements are capable of higher operating temperatures and because their thermal insulating capacity is great, they deteriorate slowly. In the case of metallic friction materials there are no internal chemical changes before the melting point, and deterioration can only come from oxidation or physical changes. At the same time, however, other characteristics of these materials may have a compensating influence on selection for a particular application.

Surface Temperature: While it is reasonably easy to measure the speed of rubbing surfaces and to estimate the pressure, the temperature of a pair of rubbing surfaces is difficult to determine. Specialists in friction analysis have never come to agreement as to where or how temperature should be measured, nor have they agreed as to what it means if it is measured. It may be said with reasonable assurance of acceptance that there is no such thing as *the* temperature of the rubbing surfaces. There is, without doubt, a range of temperature.

The lowest temperature of the surface may be the extrapolated value of a curve which may be determined experimentally by measuring with thermocouples the temperature at a series of points successively closer to the surface. The maximum temperature of the rubbing surfaces will be the melting temperature of the lowest-melting-point major metal. Thus, if the brake lining is pure copper and the drum material pure iron, the maximum temperature of the interface will be the melting temperature of copper. The degree of approach of the minimum temperature to the maximum will depend upon the amount of energy to be absorbed by the friction mechanism and upon the time involved.

A cautious and reasonable approach to the temperature question will help in correctly appraising the effects of heavy duty braking under extreme energy absorption service. The immediate effect of high temperature in a brake is wear, either on the brake lining or the drum.

High-temperature resistance to wear is increased in molded linings by increasing the amount of inorganic material, such as metals, graphite, oxides, and ceramics, in the lining. Near the surface, if the organic binder is destroyed by heat, the ceramic fillers remain and continue to have body and friction properties. The melting temperature of the remaining ceramics is relatively high, and may be higher than that of the steel. If the latter is true, then scoring and general damage to the drum may ensue, because the maximum temperature reached at the surface will be the melting temperature of the drum, instead of the lining. If sintered-metal linings are employed, and the melting point of the matrix metal is substantially lower than that of the drum, it is not likely that the metal lining will damage the drum for reason of high melting point.

They Say . . .

"There are still a few who believe that standards freeze designs and that by incorporating standard parts, the usefulness of the product will be limited. These people do not fully understand the nature of standards. Standards are not museum pieces put on a pedestal for all eternity. No standard is rigidly fixed. All standards are subject to changes dictated by usage. Standards are dynamic, not static. Under ASA rules, for instance, all American Standards are reviewed periodically and revised when necessary.

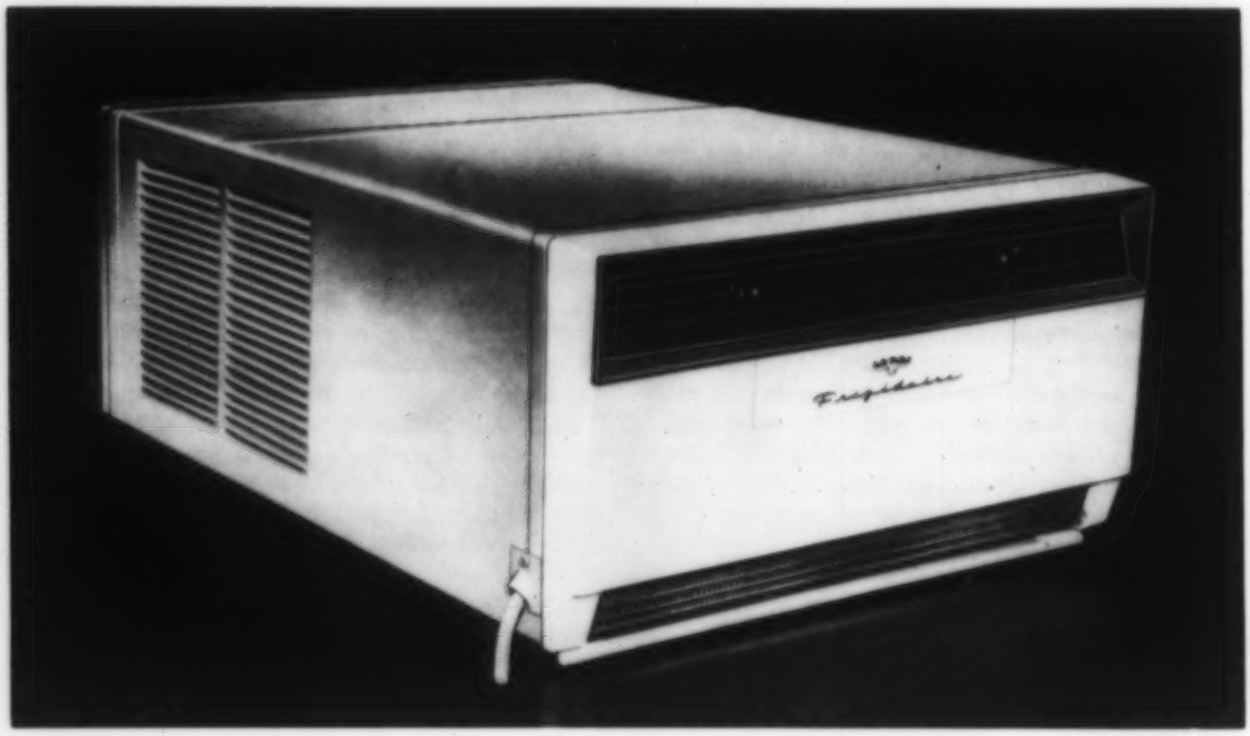
"Like all other creative methods and tools, standards are in constant flux. Like the words of our language, which are nothing but standards of speech, we need the standards of industry and economy to carry on our daily business. But no one today speaks the language of Shakespeare. We have adapted our language to new ideas and to new needs. Technology itself has probably created the greatest influx of new word standards into our language since its origin. In fact, most new technical standards cannot be developed until we have standardized on the terminology. In our experience with standardization it has happened more than once that engineers used different terms and it took them a while to find out that they were really talking about the same thing." — CYRIL AINSWORTH, *technical director and assistant secretary, American Standards Association.*

"We can all improve the effectiveness with which we express ideas and thereby increase our engineering competence, if we just follow a few basic rules. One of these is to use simple methods of expression that state accurately what we want to say, and mean the same thing to our listeners or readers.

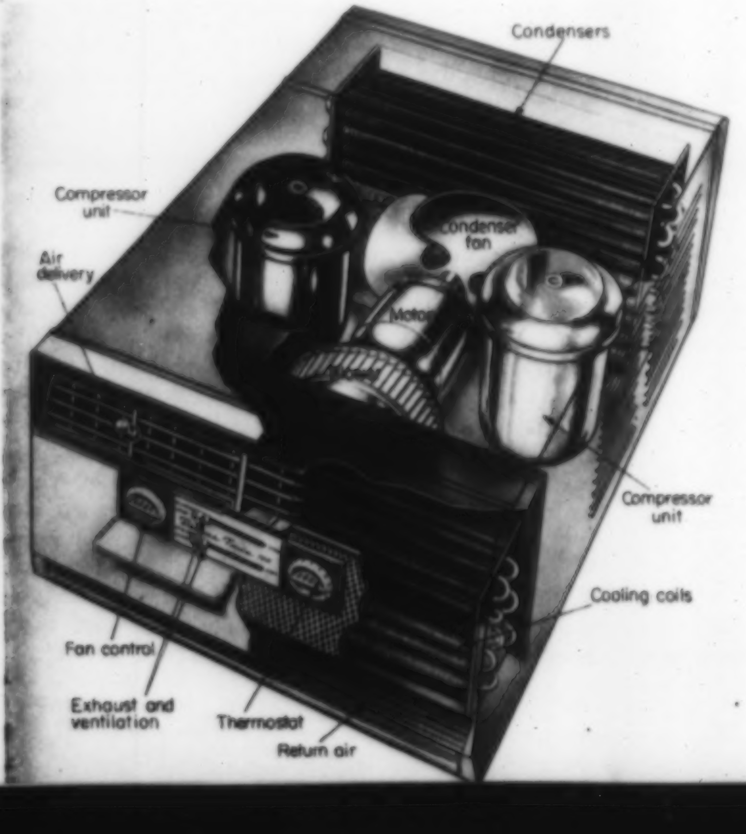
"This frequently means that we have to abandon a complicated piece of engineering jargon of which we may be very proud because it sounds so satisfyingly technical. But just remember that your reputation will be built on how well you get your ideas across, rather than how technical and scientific you sound." — JAMES C. ZEDER, *vice president, engineering, Chrysler Corp.*

CONTEMPORARY DESIGN

Air Conditioners Use Two Cooling Systems



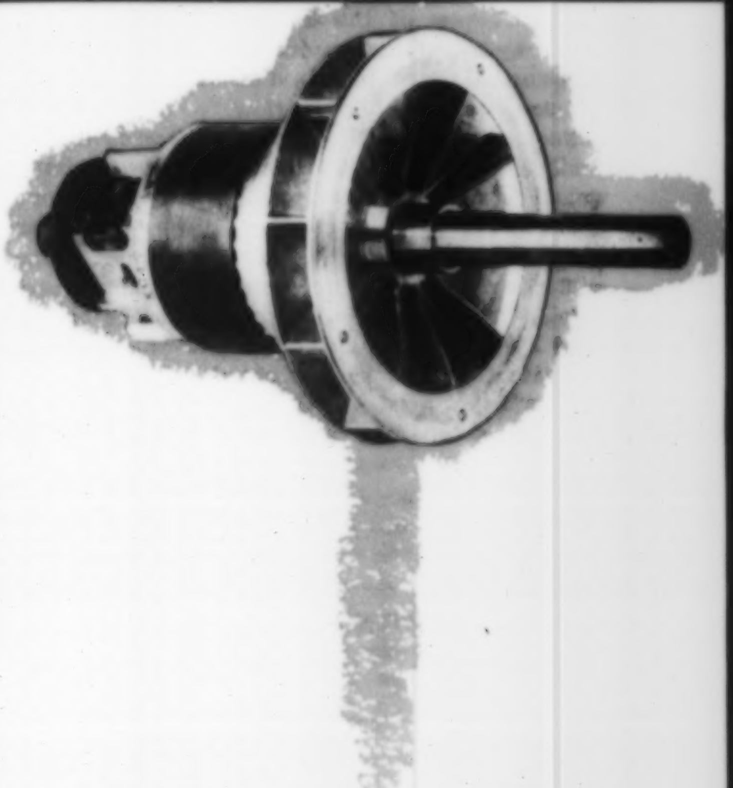
A NEW series of room air conditioners incorporates dual cooling systems to provide a wide range of cooling capacities and reduce electric power consumption when full cooling is not required. Available in ¾ and 1-hp models, the units are 26 inches wide, 13⅞ inches high and 36⅝ inches deep. Cooled air may be recirculated room air, outside air or a combination of both. In addition to their primary function of cooling, the Frigidaire air conditioners may be used to exhaust stale air from the rooms in which they are installed. Cooling may also be combined with moderate exhaust action.


Condensers
Compressor unit
Air delivery
condenser fan
Motor
Compressor unit
Cooling coils
Fan control
Exhaust and ventilation
Thermostat
Return air

Separate cooling systems have individual compressors, condensers and cooling coils. Dark condenser and cooling coil function with the dark-colored compressor unit, while the light-colored units make up the other system. Compressors are hermetically sealed and permanently lubricated.

Another interesting design feature of these air conditioners is the use of cabinet and chassis construction. The entire operating mechanism may be removed from the metal enclosure for inspection or servicing. This eliminates any necessity of disturbing the mountings, once the unit is installed.

Design Characteristics of Radial-Flow Fans



How to determine basic fan proportions and blade configurations to get desired air flow and pressure

By L. W. Wightman
General Electric Co.
Schenectady, N. Y.

THE PURPOSE of a radial-flow fan is to force or induce air to flow through a restriction. For the air flow to occur, a difference in pressure must be created. Therefore, the static pressure a fan will produce across a given restriction is a basic parameter of its performance. The full fan performance is determined by varying the restriction from the condition of no air flow to that of free flow or no restriction.

Why Radial-Flow Fans Work: The motivating force which makes radial-flow fans function is cen-

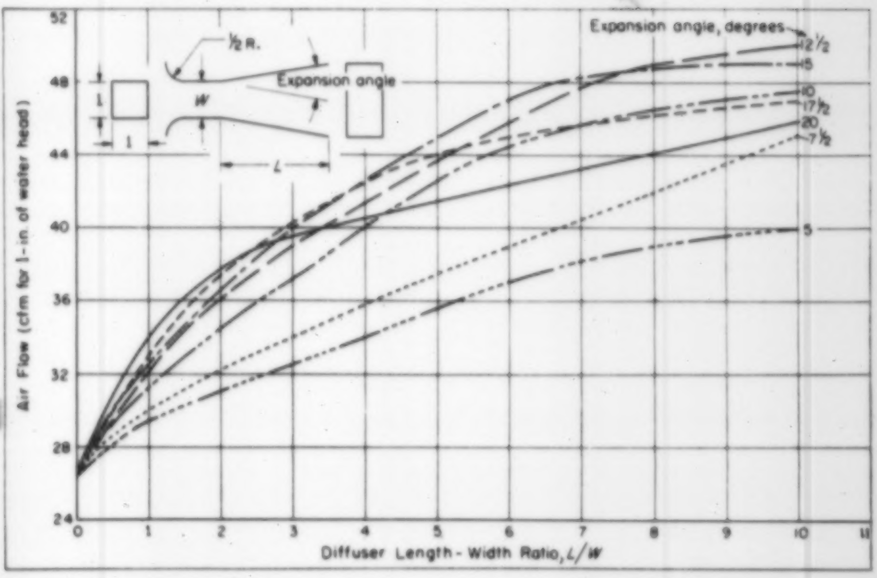


Fig. 1—Effectiveness of expansion diffusers in increasing air flow

trifugal force on the air particles within the fan blades. For this motivating force to be effectively utilized, however, efficient diffusion must take place within the fan and beyond the fan exhaust. While centrifugal force is generally understood, the diffusion process is not. Diffusion, in this case, means the conversion of the energy air has because of its velocity to static-pressure energy. This conversion is accomplished by slowing the air down gradually by means of a gradually enlarging airflow passage. If the passage is enlarged too abruptly, the velocity energy is converted into heat by friction between the air particles instead of into static pressure. If the passage is enlarged too slowly, much of the velocity energy is converted into heat by friction between the the air and the passage walls.

Effectiveness of the diffusion process is illustrated by *Fig*. 1. These curves show the optimum diffusion passages. Increased effectiveness is shown by increased quantity of air flow.

Now just how does centrifugal force on the air particles in the fan blades combine with the diffusion process to make the radial-flow fan function?

In *Fig*. 2 is shown a typical radial-flow fan. When the fan is revolving, the air at *B* spins around with the fan blades. Because of its spinning, centrifugal force (a radial force) moves the air toward *C*. When this happens, a low-pressure area is created at *B* so that the air at *A* flows toward *B*. If the air must go through a restiction *R* to get to *A*, a low-pressure area is maintained at *A* too. As the air goes through the fan and passes *C*, the fan no longer has any effect on it, so the air keeps going in the direction it has when it approached *C*, which is toward *D*. Air velocity at *C* is the resultant of radial velocity and peripheral or spin velocity.

A schematic drawing of this occurrence is shown in *Fig*. 3. Here, air at atmospheric pressure is induced through the restriction *R* to the low-pressure area *A*. From *A* it goes through the entrance restriction into the fan blades at *B* where centrifugal force impels it to *C*. From this point it is exhausted to atmospheric pressure again at *D*. Note that diffusion between the fan blades from *B* to *C* will increase air flow just as it did in *Fig*. 1 because, relative to the fan, the velocity at *C* is lower than the velocity at *B*. However, relative to the atmosphere, the absolute velocity at *C* is higher then at *B*. This is because peripheral or spin velocity always increases more from *B* to *C* than radial velocity decreases.

The high absolute velocity at *C* is always available for conversion to static pressure by diffusion. If the air is further diffused from *C* to *D*, most of the velocity energy that was put into the air can be converted into static pressure and added to the static pressure created by centrifugal force. In a radial-blade fan the pressure equivalent of the discharge velocity is approximately equal to the static pressure created by centrifugal force. Thus, the total static pressure which a fan and complete diffusion can produce is approximately twice that produced by centrifugal force alone.

Now how much static pressure can centrifugal force produce?

For a radial-blade fan as shown in *Fig*. 2 where the angular velocity of all the particles within the fan blades is the same, the static pressure from centrifugal force is

$$H_{cf} = \frac{V_c^2 - V_b^2}{4000^2} \qquad (1)$$

where H_{cf} = static pressure from centrifugal force,

Fig. 2—Typical radial-flow fan, *a*, showing velocities imparted to the air by fan rotation, *b*

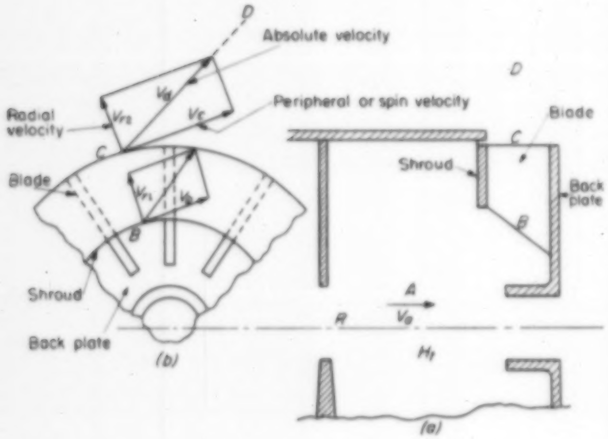


Fig. 3—Flow diagram of the fan in *Fig*. 2

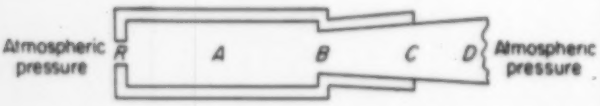
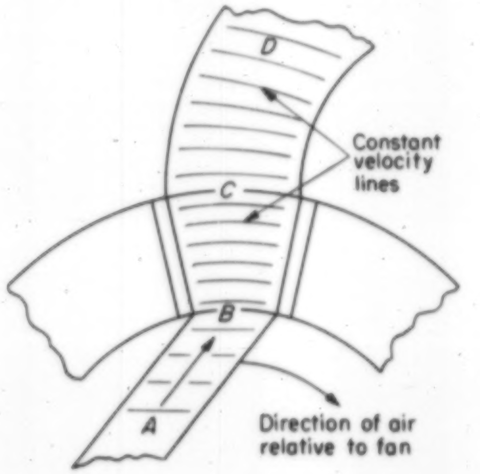


Fig. 4—Air path relative to the fan



inches of water; and V_b and V_c = peripheral or spin velocities at *B* and *C*, respectively, fpm.

Total theoretical pressure H_t which occurs at *A* in *Fig.* 2*a* if there is complete diffusion within the fan blades and from *C* and *D* beyond the fan blades is determined by:

1. Assuming the ambient pressure surrounding the setup shown in *Fig.* 2*a* to be constant.
2. Assuming velocity V_a at *A* to be zero.
3. Letting the pressure at *A* equal H_t.

All symbols are as shown in *Fig.* 2, and all velocities are in feet per minute. Then, starting from *D*, the static-head drop from *D* to *C* equals

$$\frac{V_{r2}^2 + V_c^2}{4000^2}$$

Centrifugal-force static-head drop from *C* to *B* is

$$\frac{V_c^2 - V_b^2}{4000^2}$$

Static-head drop by diffusion from *C* to *B* equals

$$\frac{V_{r1}^2 - V_{r2}^2}{4000^2}$$

Static-head drop from *B* to *A* equals

$$\frac{V_a^2 - V_{r1}^2}{4000^2}$$

The total theoretical pressure H_t in inches of water will then equal the total static-head drop from *D* to *A* which will also equal the total head drop across *R*:

$$H_t = \frac{V_{r2}^2 + V_c^2 + V_c^2 - V_b^2 + V_{r1}^2 - V_{r2}^2 + V_a^2 - V_{r1}^2}{4000^2}$$

and

$$H_t = \frac{2V_c^2 - V_b^2}{4000^2} \qquad (2)$$

If there is no diffusion from *C* to *D*, then

$$H_t = \frac{2V_c^2 - V_b^2 - V_{r2}^2 - V_c}{4000^2}$$

or

$$H_t = \frac{V_c^2 - V_b^2 - V_{r2}^2}{4000^2} \qquad (3)$$

But for any fan with forward or backward-curved blades, the angular velocity of the air at *C* is different from the blade velocity except at zero flow. Some writers neglect this factor and derive equations for such fans, but since the equations couldn't be used numerically even if correct physically, they will be omitted. However, Equations 2 and 3 do show the advantages of making V_b as small as possible by using either curved-inlet or deep blades.

Air Flow Through the Fan: Additional schematic arrangements of the fan in *Fig.* 2 are shown in *Figs.* 4 and 5. *Fig.* 4 shows the air path relative to the fan. *Fig.* 5 shows how the fan looks to a section of the air stream as it approaches, goes

Fig. 5—Actual path of a segment of air going through the fan. Blades are actually straight, but appear curved

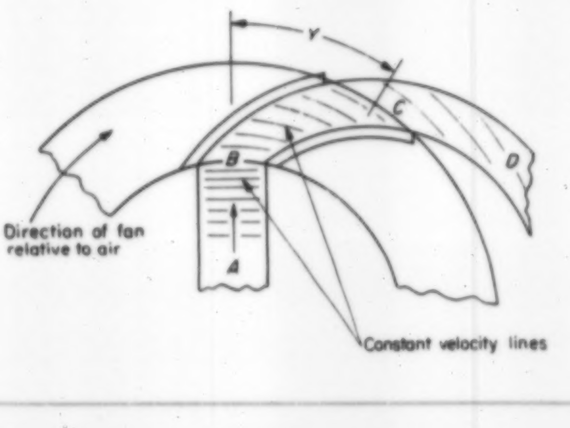
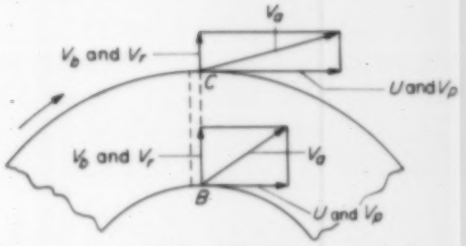
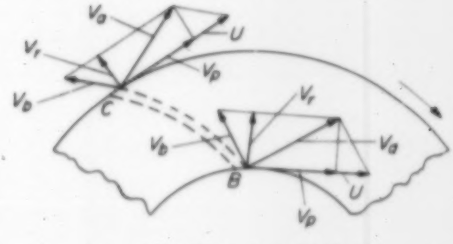


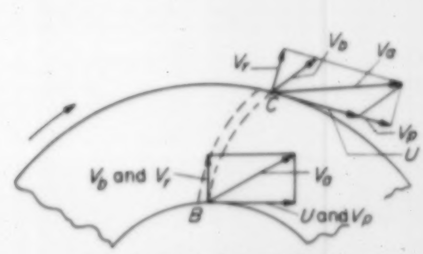
Fig. 6 — Air velocity vectors for three different blade types



(a) Radial Blade



(b) Back-Curved Blade



(c) Forward-Curved Blade

through and exhausts from the fan. Between the time the section of the air stream enters B and leaves C, it has turned through some angle Y which makes the radial blades appear to be curved as shown.

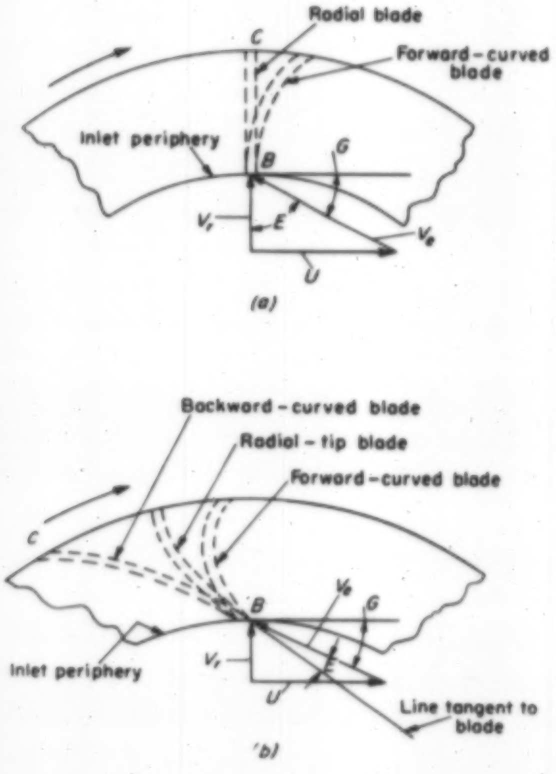
What Happens as Air Enters the Blades?: In *Fig.* 6 are shown velocity vector diagrams for radial, back-curved, and forward-curved blade fans. In all cases B represents the air entrance and C the air exit from the fan blades. Nomenclature is the same for inlet and exit conditions, and vector notation is as follows:

V_b = Air velocity in direction of or tangent to blade
V_r = Air radial velocity
U = Blade peripheral velocity
V_p = Air peripheral velocity
V_a = Air absolute velocity

In all cases, V_a is the resultant of U and V_b, and V_r and V_p are radial and peripheral components of V_a.

The vector values in *Fig.* 6 are, in each case, for just one particular resistance as, for instance, R in *Fig.* 2. Here R represents all the resistance in the system except the fan resistance. For a given resistance R, the vectors all keep their same relative values when the fan speed or U changes. At

Fig. 7—Entrance-air velocity vectors, showing impact angles for radial blades, *a*, and backward-curved inlet blades, *b*



Fan Laws

The fan laws are relations which allow the characteristics of a given fan operating at a given speed to be used to determine those of a similar but different-size fan operating at a different speed. These relations are quite accurate for small changes in size and speed, and fairly accurate for changes of three or four to one in speed and two or three to one in size. However, all the characteristics change slightly with increasing size so that the efficiency is gradually increased. This is probably because the boundary layer of air along the surface of the fan does not change in the fans in proportion to the size change. Constant density conditions are assumed.

Nomenclature

D = Diameter of fan periphery, inches
H = Static head, inches of water
N = Fan speed, rpm
P = Power input, hp
Q = Air flow, cfm

Fan Relationships

$$H \propto Q^2$$

$$P \propto Q^3$$

$$P \propto H^{3/2}$$

For a given fan with varying rotational speed,

$$H \propto N^2$$

$$Q \propto N$$

$$P \propto N^3$$

For similar fans in combination with similar restrictions,

$$H \propto N^2D^2$$

$$Q \propto ND^3$$

$$P \propto N^3D^5$$

Approximate fan laws for similar fans where fan dimension ratios are not greater than 1.5:1, and where external restriction of the larger fan is more than 2 times that of the smaller fan and is constant, are as follows. These laws are primarily for different-diameter fans used on the same electric unit:

$$H \propto N^2D^2$$

$$Q \propto ND$$

$$P \propto N^3D^3$$

zero flow, V_b and $V_r = 0$; and $V_a = V_p = U$.

When R changes, all of the vector values in the *Fig*. 6 diagrams change except U and V_p where the blade is radial.

At free flow, V_p, V_r and V_a are maximum; for backward-curved inlet, V_p is minimum; and for radial inlet $V_p = U$.

The vectors in *Fig*. 6 can be shown in *Fig*. 7. Here V_e is the resultant of V_r and U. V_e is the entrance vector relative to the fan blades. The angle E between the entrance vector V_e and the blade is the impact angle between the entering air and the blade. For a constant fan speed or U, V_r increases as the resistance R decreases, and the quantity of air flow increases. When V_r increases and U remains constant, the impact angle decreases. *Fig*. 7*b* shows how the backward-curved inlet decreases the impact angle compared to the radial blade in *Fig*. 7*a* for similar blade radial depths operating under the same conditions of speed and resistance. As the blade radial depth increases, U becomes smaller for a given fan speed; hence the impact angle E decreases.

An angle G between the entrance vector V_e and a tangent to the inlet periphery is also shown in *Fig*. 7. The angle G determines the actual inlet area to the fan blades. The actual inlet area is the sine of the angle G times the product of the fan width and the inlet periphery. Allowances must be made for tapered inlet blades as shown in *Fig*. 2. Therefore, as resistance R decreases and flow increases, the actual inlet area automatically increases. However, this increase is at a slower and slower rate as free flow is approached.

The diagrams in *Figs*. 6 and 7 show that in many cases the absolute entrance air velocity V_r changes to a much higher absolute velocity V_a at the instant the air enters the fan blades at B. This extremely high acceleration creates shock loss in the form of heat. All energy input to the fan which goes to create heat cannot be used to create static pressure and is therefore wasted. To keep the inlet shock loss to a minimum, several arrangements can be used depending on the fan requirements. Some basic arrangements are:

1. Backward-curved blade at the inlet as shown in *Figs*. 6*b* and 7*b*.
2. Deep blades radially to decrease U. This has the advantage of higher centrifugal force and longer diffusion, producing greater static pressure, but it has the disadvantage of throttling the air inlet through the shroud under high flow conditions.
3. A compromise tapered-blade fan as shown in *Fig*. 2. This has the advantage of deep blades combined with an open inlet through the shroud.
4. A tapered-blade fan as shown in *Fig*. 2 with backward-curved blades at the inlet edge. This combines the benefits of minimum shock loss, deep blades, and open inlet through the shroud.

For medium to high flow conditions, another im-

Fig. 8—Expansion loss at inner edge of straight fan shroud, *a*, which can be minimized by proper inlet orifice design and curved shroud, *b*

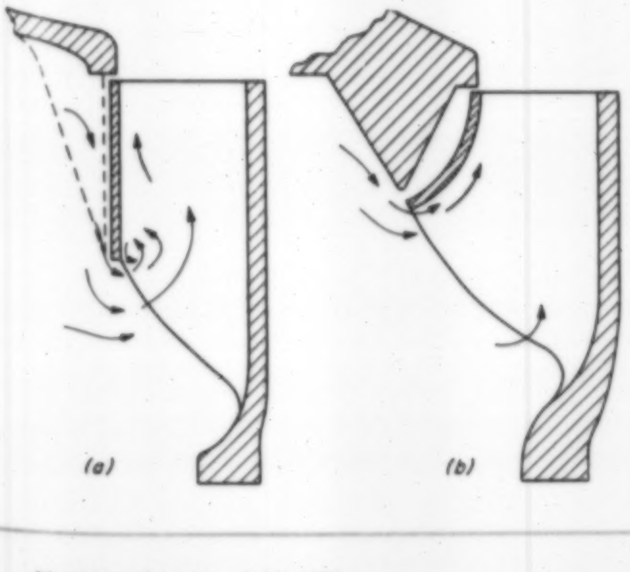
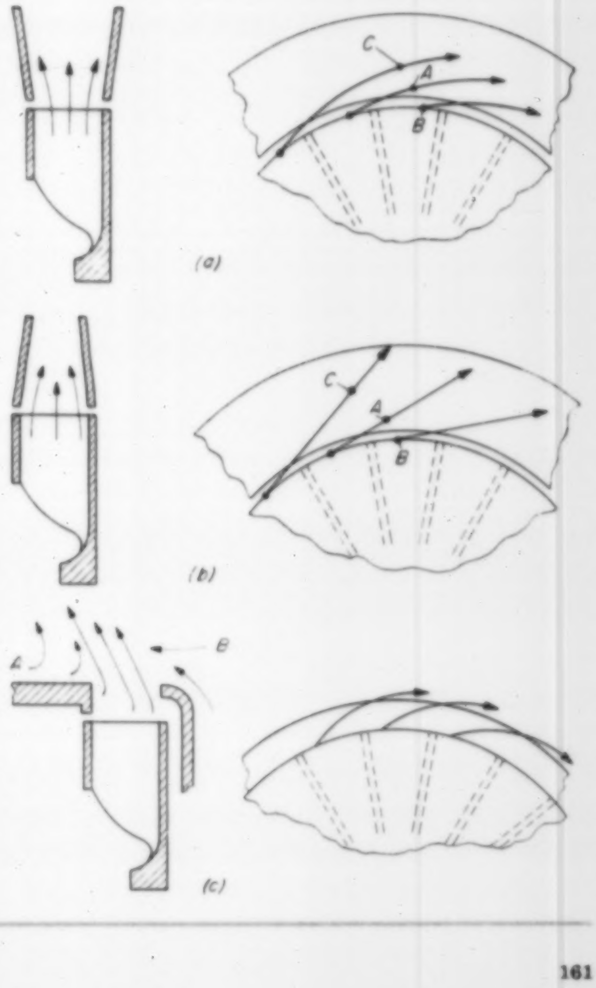


Fig. 9—Typical exhaust conditions, and air flows after leaving the fan



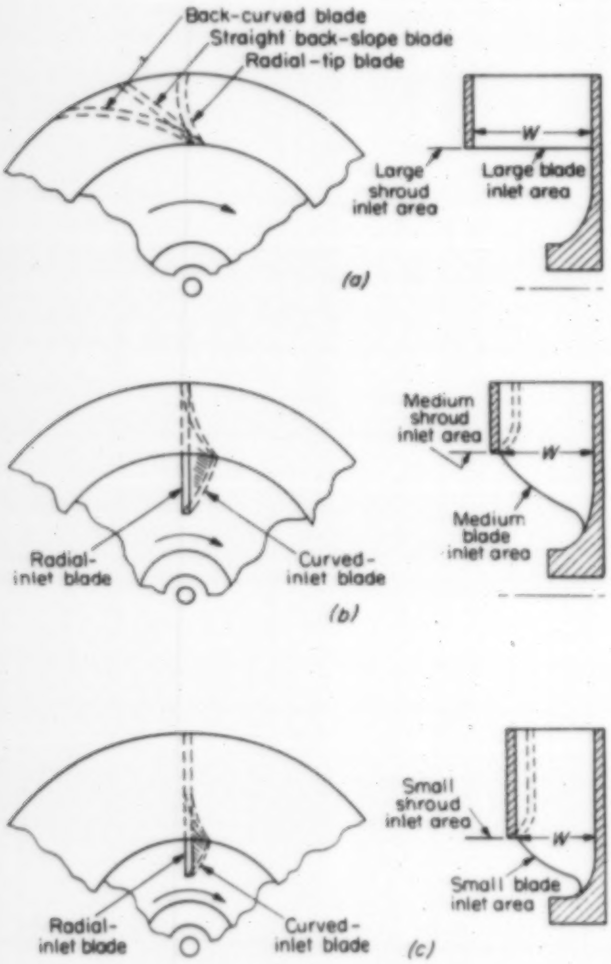

Back-curved blade
Straight back-slope blade
Radial-tip blade
W
Large shroud inlet area
Large blade inlet area
(a)
Medium shroud inlet area
W
Medium blade inlet area
Radial-inlet blade
Curved-inlet blade
(b)
Small shroud inlet area
W
Small blade inlet area
Radial-inlet blade
Curved-inlet blade
(c)

Fig. 10—Relative inlet proportions for high-flow, low-pressure work, *a*; medium flow and pressure, *b*; and high pressure and low flow, *c*

portant inlet loss occurs as shown in *Fig.* 8*a*. An expansion loss occurs within the fan just back of the inner edge of the shroud. This can be partly overcome with a tapered-inlet orifice as shown dotted. However, the expansion loss can be completely overcome with the inlet orifice and curved shroud as shown in *Fig.* 8*b*. The arrows in *Fig.* 8 do not represent true direction. They represent only the radial component to which must be added the peripheral component for an accurate mental picture.

What Happens as Air Leaves the Fan Blades: Again refer to *Fig.* 6 where the velocity vector diagrams at the fan exit *C* are shown for backward-curved, radial and forward-curved blades. Here again the vector values are for just one particular resistance *R*. The vector values at *C* are shown relative to those at *B* or for the same resistance *R*. Note that V_b decreases because of the diffusion within the blades. The peripheral air velocity V_p is less than *U* for backward-curved blades, equal to *U* for radial blades and greater than *U* for forward-curved blades. This is true for all conditions except zero flow. Therefore, except at zero flow or for radial-blade fans, centrifugal force is not a direct function of *U*. It is a function of *U* and the blade angle at each increment of radius from *B* to *C*. This situation is far too complicated for any reasonable calculation.

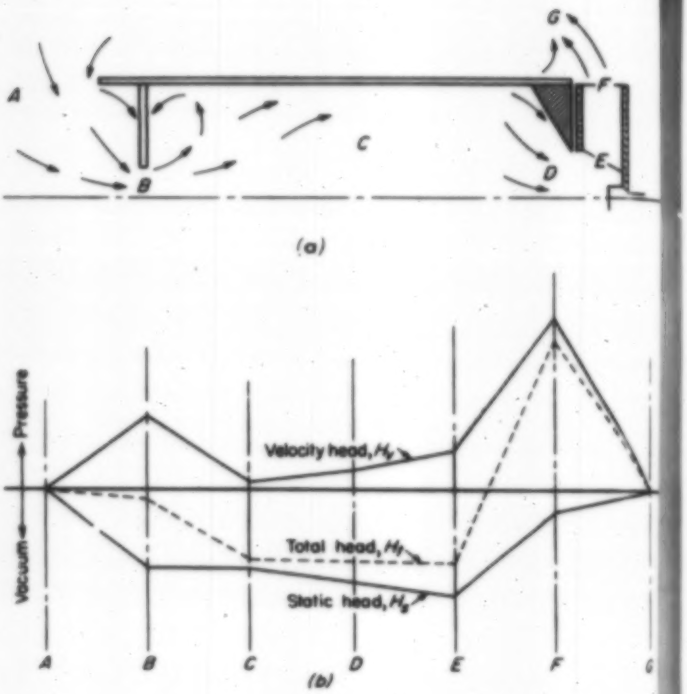

G
A
F
C
E
B
D
(a)
Pressure
Vacuum
Velocity head, H_v
Total head, H_t
Static head, H_s
A
B
C
D
E
F
G
(b)

Fig. 11—Typical induced-draft fan system, *a*, and air pressure at different points within the system, *b*

The absolute exhaust velocity V_a is the velocity which must be diffused to obtain the maximum static pressure. However, the diffusion of V_a will not be covered here except to point out that at zero flow, where V_r is zero, the exhaust goes around and around with the fan and never comes out, so the air can't be diffused. Also, there is no air flow and hence no diffusion through the fan blades. Therefore, at zero flow, the only static pressure developed is that created by centrifugal force. As the restriction *R* is decreased and the airflow increases, V_r increases so that diffusion can take place. Thus, the static pressure can increase above that developed at zero flow.

The exhaust velocity vectors in *Fig.* 6 are for the particular point *C* only. After the air leaves *C* it does not necessarily follow in the direction of V_a. *Fig.* 9 shows some typical exhaust conditions. In *Fig.* 9*a*, the radial path expands after exhaust. Thus, the air slows down rapidly after leaving the blades and continues to spiral around the fan as shown. To understand this action, consider point *A* in the air stream. Here the velocity is lower than at point

B but higher than at point *C*. Total pressure is about the same at all three points. Therefore, the static pressure is lower at *B* and higher at *C*, which forces the air stream to spiral as shown.

In *Fig.* 9*b*, the radial path converges so that the air velocity is maintained. Here, the velocities at *A*, *B*, and *C* are about the same, so the air path is not deflected. In *Fig.* 9*c*, where the air exhausts into the open, the path is spiralled more than in *Fig.* 9*a*. Here also is shown a case where the external enclosure is extended on side *A* and cut off on side *B*. In this case the air will spiral toward side *A* rather than radially, because the exhaust air picks up the surrounding air and carries it along. There is more air available on side *B* than on side *A*, so the static pressure on side *A* becomes less than on side *B*. Hence, the exhaust air is forced toward side *A*, as shown.

Effect of Number of Fan Blades: The best number of fan blades is determined by the type of fan and its application. A radially-deep, backward-curved-blade fan for high-efficiency, high-pressure work where the speed is not limited might properly have only four or five blades. A radially-shallow, forward-curved-blade fan for high-flow, low-pressure work might properly have thirty or more blades.

In general, the number of blades should be the minimum number required to obtain proper diffusion. Too many blades increase surface friction loss and over-restrict the air inlet passage to the blades. Too few blades allow the air to expand too rapidly for proper diffusion and may allow back flow between the blades in the operating pressure range. For any type fan, there is generally a wide number of blades between too many and too few where fan operation is about the same.

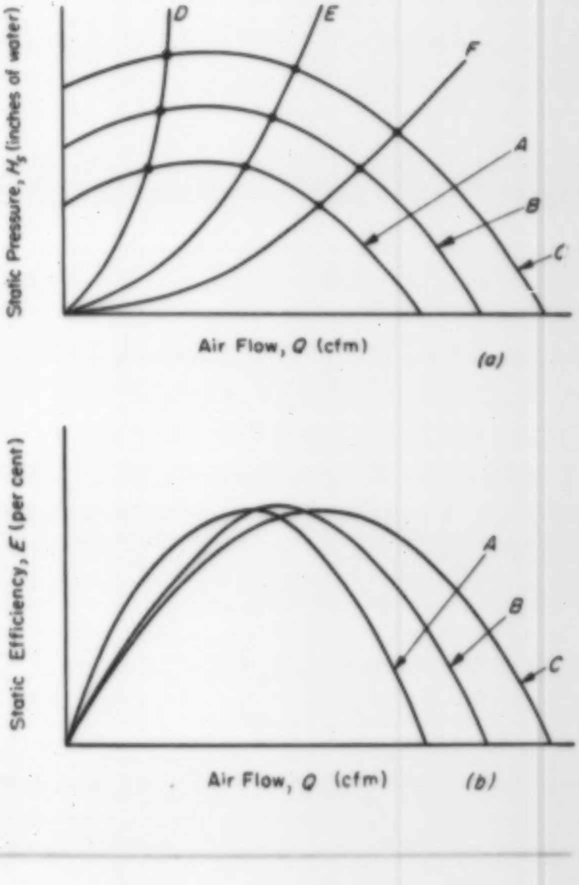
The radially-shallow, forward-curved type fans for low-pressure work will not function without some sort of exhaust diffuser, since there is practically no diffusion in the fan blades and the blades are not radially deep enough to produce much static head from centrifugal force alone. For this reason, this type fan will not be discussed further here.

Effect of Blade Width and Shroud Depth: Blade width and shroud depth are interdependent and must therefore be considered together. Together they determine the fan resistance to air flow as shown in *Fig.* 10. Fan restriction to air flow should be small compared to the load restriction, such as *R* in *Fig.* 2. As the load restriction decreases and approaches the fan restriction, more and more of the static pressure produced by the fan is required to force air through the fan itself, and less is available to induce air through the load restriction. However, as the fan blades and the shroud are made radially deeper, static pressure produced by the fan increases. Eventually the increase in static pressure is offset by the increase in fan restriction. Therefore there is an optimum fan blade and shroud depth for each load restriction. Likewise there is an optimum width *W* and blade inlet area for each shroud depth. If the blade width *W* and blade-inlet area are too small compared to the shroud inlet area, they will offer excessive restriction and use up an excessive amount of the static pressure produced by the fan. If the blade width *W* and the blade inlet are are too large compared with the shroud inlet area, the radial component of flow, V_r in *Fig.* 6, will be too small, and excessive impact loss will result.

Relative proportions for high-flow, low-pressure work are shown in *Fig.* 10*a*. Here, backward-curved blades are often used, at the expense of static pressure and flow, to obtain high efficiency. For a given rotational speed, greater static pressure and, therefore, flow can be obtained with radial tipped blades at the expense of efficiency. Blade width *W* is large to provide a large blade inlet area to correspond to the large shroud inlet area. These large areas yield a minimum of fan restriction to correspond to the small load restriction accompanying high-flow, low-pressure work.

Relative proportions for medium-flow, medium-

Fig. 12 — Characteristic fan curves, *a*, showing effects of increasing fan speeds (curves *A*, *B* and *C*) and of increasing flow areas (curves *D*, *E* and *F*). Efficiency curves at *b* are for same speeds as in *a*



pressure work are shown in *Fig.* 10*b*. A straight radial blade is shown in full lines and a backward-curved inlet with a curved shroud is shown in dotted lines. The latter will produce a higher static pressure, hence more flow as well as greater efficiency. Blade width *W* is such that air flow area through the blades and at the blade inlet correspond to the shroud inlet area. The shroud inlet area is smaller than in *Fig.* 10*a* because of the requirement for deeper blades to produce high static pressure. This decreased shroud inlet area is still proportional to the load restrictions which in this case will be higher than for the fan in *Fig.* 10*a*.

Relative proportions for high-pressure, low-flow work are shown in *Fig.* 10*c*. This fan is quite like that in *Fig.* 10*b* except for deeper, narrower blades, and the same discussion holds true except that there is less advantage in the backward - curved inlet blade. This is because peripheral velocity of the blades at the inlet is very small compared to the radial velocity of the air at the inlet, and there is not excessive shock loss with radial blades. Also, peripheral velocity of the blades at the inlet is small compared to peripheral velocity of the blades at the outlet, so the shock loss for deep blades is smaller relative to the static pressure produced than for shallow blades.

Effect of Fan Surface Smoothness: Effect of surface smoothness is negligible up to peripheral speeds around 8000 fpm. Above this speed, rough cast surfaces may affect performance slightly but smooth cast surfaces have been used at speeds around 12,000 fpm with no appreciable change in performance upon polishing the surfaces.

What Makes Efficiency?: The most important factors in creating high efficiency are:

1. Minimum of abrupt increases in the section area of air flow paths into, through and out of the fan.
2. Minimum rate of change in direction of air flow as it enters and goes through the fan.
3. Fan-blade width and depth, shroud depth, and fan contours in proper relation to each other and to the load resistance.

Maximum efficiency is not always the goal, or all fans would have steep backward-curved blades. In many applications, the goal is a rate of air flow under conditions of limited rotational speed and fan diameter such that fans with backward-curved blades are not adequate. In other cases, fans must be reversible, which makes a curved blade of any sort impractical. In any case, the fan which will do the job required can be designed to be relatively efficient.

Efficiency of any fan operating alone will never be as great as it would be with a properly designed exhaust diffuser.

There are two general ways to relate the fan output to fan efficiency. One is based on the air flow and static pressure produced by the fan, while the other is based on the air flow and static pressure plus the exhaust-velocity pressure produced by the fan. Here only the former, or static efficiency, will be considered. The latter is generally deceiving because the exhaust-velocity pressure is almost always wasted or negligible, and there is no standard way to measure it.

Static efficiency is expressed as

$$E = \frac{0.118\,HQ}{W}$$

where H = static pressure, inches of water; Q = air flow, cfm; and W = input to the fan, watts.

Fan Characteristic Curves: Fig. 11*a* shows a setup similar to that shown in *Fig.* 2. This is a typical induced-draft system in which all the load or resistance other than that in the fan itself is concentrated at one place, point *B*. The other system areas at *A* and *C* are so large relative to the area at *B* that they offer negligible resistance. This

Fig. 13—Development of a fan characteristic curve

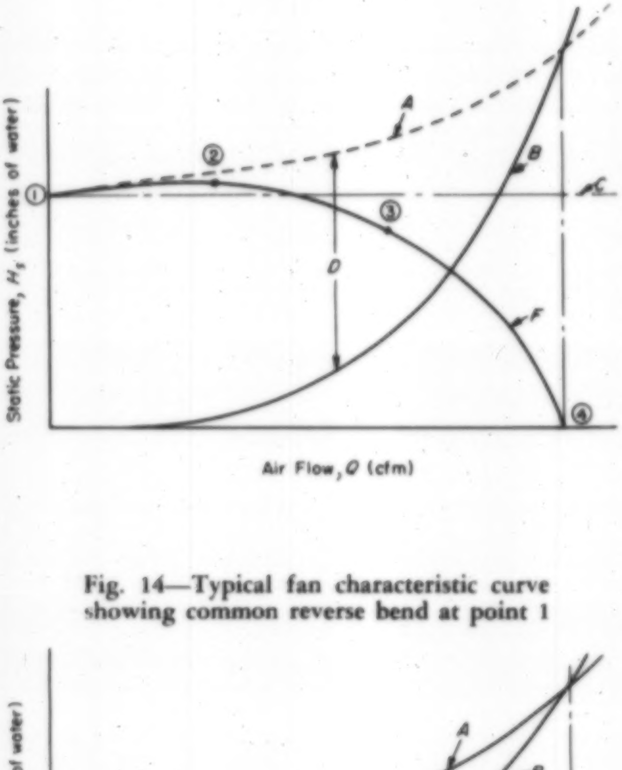
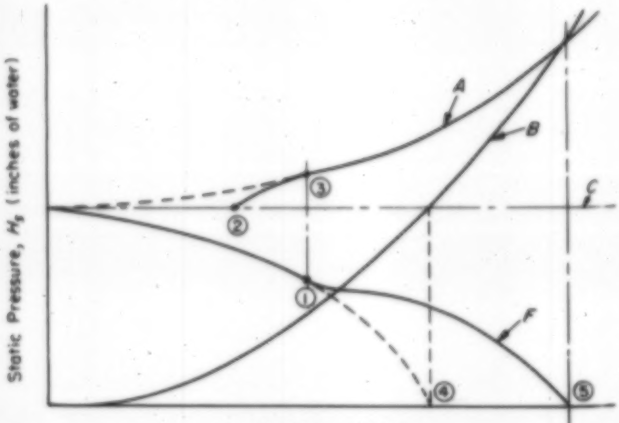


Fig. 14—Typical fan characteristic curve showing common reverse bend at point 1



system can represent any induced-draft system since the resistance at *B* can be made equivalent to any combination of other resistances.

The total head H_t of air at any point is equal to the sum of the static head H_s and the velocity head H_v both taken relative to some third point (generally the ambient atmosphere). The relation between these three values of head and the ambient atmosphere for the system shown in *Fig.* 11*a* is shown in *Fig.* 11*b*.

In *Fig.* 11*b*, the static head or pressure produced by the fan is the difference between points *F* and *E* on the H_s curve. However, the static head difference between atmosphere pressure and point *C* on the H_s curve is available for inducing air to flow through the resistance at point *B*. The static head difference between *F* and the atmosphere is produced by exhaust diffusion back over the flow pipe. Now the velocity head at *C* is just about zero or atmospheric because the cross-sectional area or flow area at *C* is so large relative to the flow area at *B* and the flow areas through the fan that the air velocity is very low. Therefore, at *C* the static head H_s and the total head H_t are about equal.

If the flow area of the restrictions at *B* is increased, the static head at *C* will induce more air to flow through the restriction. But this increases air flow through the fan itself. Therefore, there is less static head available at *C*. So while air flow through the resistance at *B* increases, the static head at *C* decreases until equilibrium is

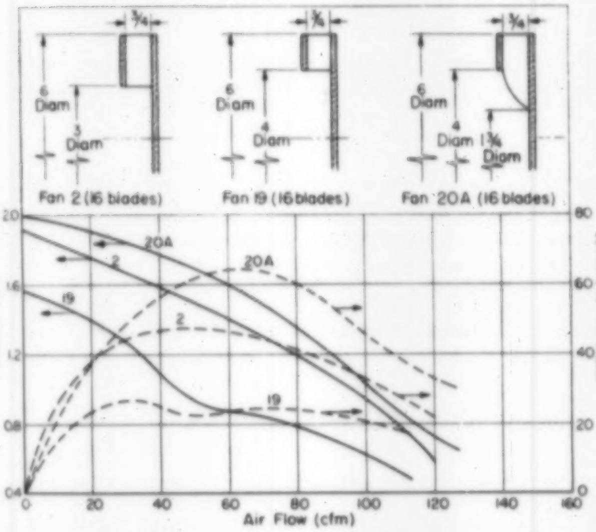


Fig. 15—Effect of blade depth on characteristic curves for radial-blade fans. Speed is 4000 rpm

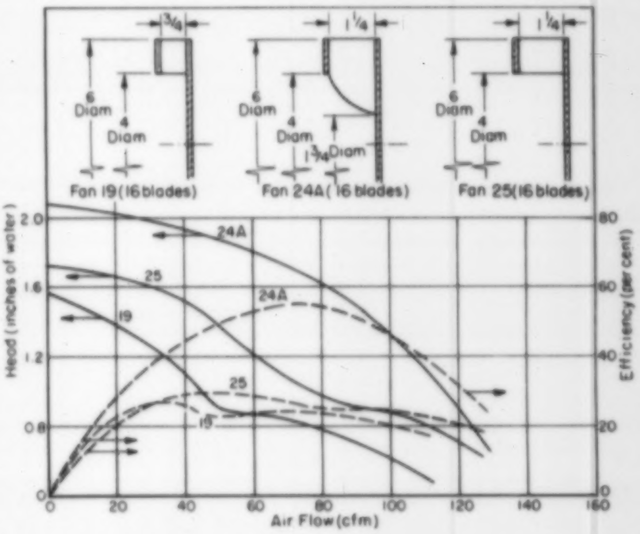


Fig. 16—Blade width comparison (radial blades; 4000 rpm)

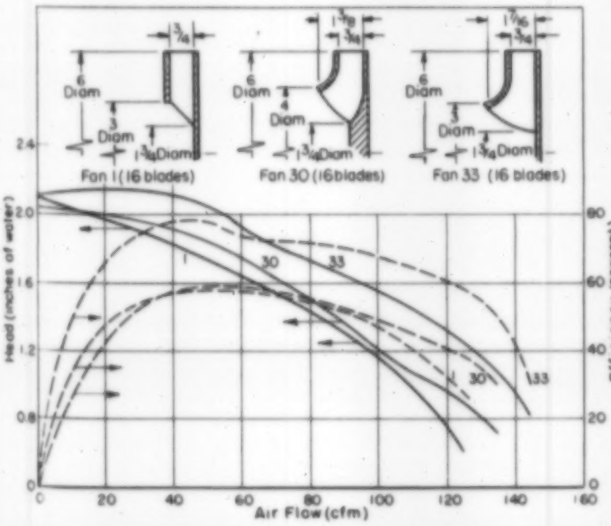


Fig. 17—Curved shroud comparison (radial blades; 4000 rpm)

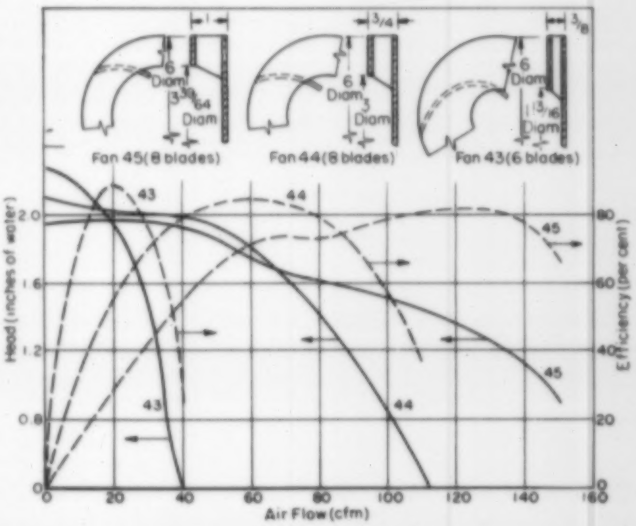


Fig. 18—Back-curved blade comparison (4000 rpm)

again reached. Thus, for a system such as that in *Fig.* 11*a*, for each flow area of the resistance at *B* there is a definite amount of air flow and static head at *C*, both of which are basically functions of the fan alone. (The term fan in this case includes the inlet orifice.) Therefore, a plot of these values of static head at *C* and air flow, as the flow area of the resistance at *B* is varied, give a curve which is characteristic of the fan. Such curves are shown in *Fig.* 12*a* as curves *A*, *B* and *C*.

The characteristic fan curves in *Fig.* 12*a* show the effect of increasing the fan speed from one speed (curve *A*) to a greater speed for curve *B* and to a still greater speed for curve *C*. On these curves the increasing flow areas through the resistance are shown from the zero flow area at the left through intersections with the increasing-area curves *D*, *E* and *F* to the infinite flow area or no resistance on the right. These last points actually require the elimination of the pipe as well as the resistance. Curves *D*, *E* and *F* in *Fig.* 12*a* are the static head vs air flow curves for three different flow areas through the resistance. These curves can only be obtained when characteristic fan curves are taken at different speeds. or when different fan characteristic curves are plotted on the same curve sheet using flow areas of the same resistance.

Efficiency curves for the same fan and the same three speeds are shown in *Fig.* 12*b*. Note that peak efficiency comes when the curves of *Fig.* 12*a* start to bend sharply down or at the intersection of area curve *E*. Peak efficiency will be at the same flow area through the resistor regardless of fan speed. Efficiency will also be the same value for each flow area across the resistance through any normal range of speed.

Some fan characteristic curves are plotted in terms of pressure coefficients and flow coefficients. The pressure coefficient is the ratio of the actual static head to the static head equivalent to the fan peripheral velocity, and is expressed as a per cent. The flow coefficient is the tangent of the angle of the exhaust velocity vector. With these coefficients, fan characteristic curves can be compared directly regardless of the fan size or the fan speed at which the curves were taken. Such a comparison is difficult, however, since a wide-blade fan which is otherwise similar to a narrow-blade fan will have a lower flow coefficient for a given resistance flow area even though the actual flow is greater. For this reason, actual values rather than coefficients will be used here.

Significance of the change of slope of the fan characteristic curve is shown in *Fig.* 13. Here point 1 represents the zero-flow static pressure created by centrifugal force on the air within the fan blades. This head is available at any value of flow and for a radial-blade fan is shown at curve *C*. Added to the static head from centrifugal force is the head created by diffusion within the fan blades, and at the fan exhaust. Such diffusion head may or may not be proportional to the airflow squared, depending on entrance and exhaust conditions, and it may be appreciable or negligible. This addition gives curve *A* which is the curve of the total available static head to induce air through both the load restriction (as at point *B* in *Fig.* 11*a*) and the fan itself. The head required to force air to flow to the fan and then through the fan itself is shown as curve *B*. Thus, the actual characteristic curve *F* is curve *A* minus curve *B*. This difference, shown as *D*, is the static head available to induce air through the load restriction alone.

The rise in the characteristic curve *F* between points 1 and 2 is possible because the static head gain by diffusion can be greater than the static head loss through the fan for low values of air flow. As the restriction flow area, and thus the air flow, is increased, the fan requires a greater and greater percentage of the total static head produced and so the characteristic curve bends back down again to point 3. This is the point of maximum efficiency.

It is where the fan begins to become a major part of the total restriction to air flow. The characteristic curve may or may not bend sharply at point 3. If it bends sharply, then the efficiency curve peaks sharply. If it runs smoothy through point 3, then the efficiency curve will have a fairly flat top.

Sharpness of the bend at point 3 is determined by the ratio of the fan shroud inlet area to the blade inlet area, and the blade angle at the air inlet to the fan. If the fan shroud inlet area is small relative to the blade inlet area, the curve will be smooth because fan restriction to air flow is then concentrated in the fan shroud inlet area which is the same regardless of the amount of air flow. If the fan blade inlet is small relative to the shroud inlet area the curve may be sharp depending on the shape or slope of the fan blades at the inlet. This is because the fan restriction to airflow is then concentrated at the inlet to the fan blades, and this restriction varies with the quantity of air flow as previously explained. Blade angle at the fan inlet can hinder diffusion at some values of air flow and aid diffusion at other values. This is the most probable case, so curve *A* is actually not likely to be uniform.

A typical reverse bend in a curve is shown at point 1 in *Fig.* 14. Such characteristics are common and probably caused by the diffusion process beginning at some point such as 2 and reaching curve *A* at point 3. The probable reason for this delay in the start of diffusion is that, at low values of air flow, the small entrance angle (as *G* in *Fig.* 7) creates such a large vortex behind the blade that it continues clear through the fan. This may happen through the entire flow range in many fans so that curve *F* goes from point 1 to 4.

Typical Performance Curves: *Figs.* 15 through 19 present induced-draft fan-performance curves which illustrate many of the basic points brought out in the previous discussion. Performance curves were obtained from an arrangement similar to that shown schematically in *Fig.* 2. They are intended to show fan proportion comparisons and trends. They are not intended as criteria of the best fan design.

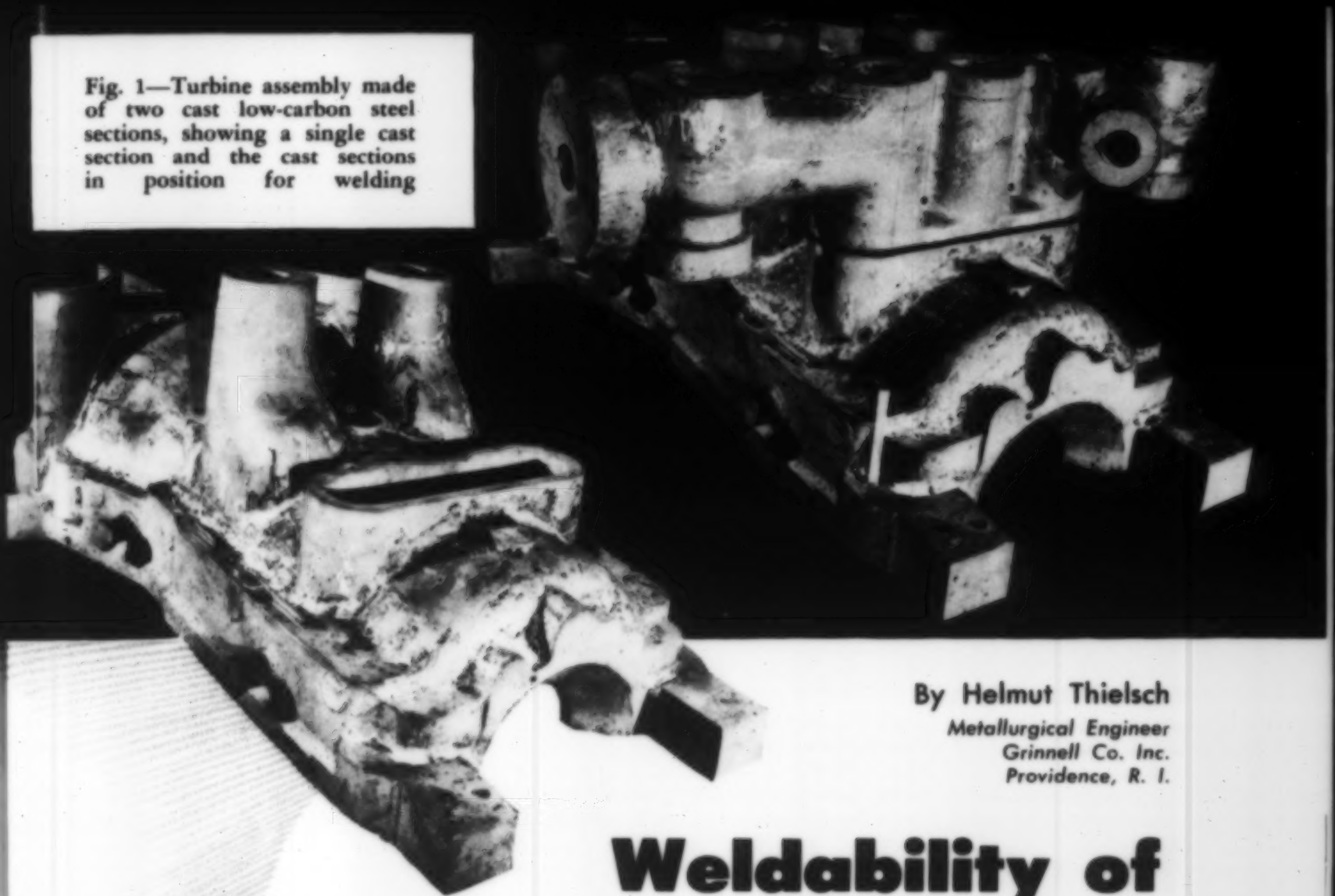


Fig. 1—Turbine assembly made of two cast low-carbon steel sections, showing a single cast section and the cast sections in position for welding

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Weldability of Cast Steels

Welding procedures, electrode specifications and heat-treatment procedures for cast carbon and low-alloy steels

THE major welding processes can be as readily applied to cast steels as to wrought steels of similar compositions. Since cast-steel sections are usually over ¼-inch thick, the welding processes suitable for joining heavier wall thicknesses are more practical. Shielded-metal arc welding with covered electrodes is most widely used. However, manual and automatic submerged arc welding processes also are extensively used, particularly in "mass" fabrication of cast-weld assemblies.

Cast steel assemblies are extensively fabricated by welding—often with a considerable reduction in weight and cost over a completely cast assembly. *Fig.* 1 illustrates the weld assembly of two cast-steel sections for a 60,000-kw steam turbine weighing 14 tons. A cast-steel pressure-vessel closure section is shown in *Fig.* 2, prior to machining for proper weld-groove preparation and welding to a rolled and seam-welded cylindrical plate body. *Fig.* 3 illustrates a center filler for a freight car.

Centrifugally cast piping is also occasionally used in piping and vessel contruction. A 5-ton hydraulic cylinder produced by welding a cast-steel cylinder to cast-steel flange sections is shown in *Fig.* 4. The cylinder operates sliding gates on reclamation projects under 1000 psi oil pressure.

In this article, the third of a co-ordinated group of articles on welding and weldments, the weldability of cast steels will be discussed, electrodes

Table 1—Welding Recommendations for Cast Steels

Cast Steel	Composition (per cent)						Welding Recommendations			
	C	Mn	Si	Ni	Cr	Mo (and others)	Electrodes[1,3]	Preheat and Interpass Temperature[2]	Postheat Treatment for Stress Relief (1 hr/in. thickness)	Notes
Low-carbon	Up to 0.25	0.50-1.00	0.30-0.60	......	......	......	E60XX	Not required	Not required	....
Medium-carbon	0.20-0.35	0.50-1.00	0.30-0.60	......	......	......	E70XX	Up to 200 F	Not required	....
	0.30-0.45	0.50-1.00	0.30-0.60	......	......	......	E70XX, E80XX[4]	200-400 F	Not required	Stress relieving is desirable where weldments are to be machined.
	0.40-0.50	0.50-1.00	0.30-0.60	......	......	......	E7015, E8015[5]	Up to 200 F	Not required	Same.
							E9015, E10015[5]	400-600 F	Recommended, 1100-1250 F	Stress-relieved specimens should preferably be cooled in furnace or under insulation.
High-carbon	Over 0.50	0.50-1.00	0.30-0.60	......	......	......	E9015, E10015, E12015[5]	400-600 F	Recommended, 1100-1250 F	For best results castings should be transferred to the heat-treating furnace immediately upon welding. If postheating is not possible, cool weldment slowly under insulation.
Molybdenum	0.20-0.40	0.50-1.00	0.30-0.60	......	......	0.30-0.65	E70XX, E80XX, E90XX[4]	200-400 F	Optional, 1100-1250 F[6]	Stress relieving is desirable where weldments are to be machined.
							E7015, E8015, E9015[5]	Up to 200 F	Optional, 1100-1250 F[6]	Same.
Chromium	0.20-0.40	0.50-1.00	0.30-0.60	......	0.70-1.10	......	E80XX-C1, E90XX-C1[4]	200-400 F	Optional, 1100-1250 F[6]	Same.
							E8015-C1, E9015-C1[5]	Up to 200 F	Optional, 1100-1250 F[6]	Same.
Chromium-molybdenum	0.15-0.40	0.50-1.00	0.30-0.60	......	0.50-1.50	0.30-0.65	E80XX-C2, E90XX-C2	200-400 F	Recommended, 1250-1350 F	For best results castings should be transferred to the heat-treating furnace immediately upon welding. If postheating is not possible, cool weldment slowly under insulation.
	0.15-0.40	0.50-1.00	0.30-0.60	......	1.75-2.25	0.40-1.20	E8015-C2, E9015-C2[5]	Up to 200 F	Recommended, 1250-1350 F	Same.
							E90XX-C3, E100XX-C3	300-600 F	Recommended, 1300-1375 F	After welding, the weld should be allowed to cool to below 600 F but not to below 300 F before applying the postheat-treatments. Allow weldment to cool under insulation.
	0.15-0.40	0.50-1.00	0.30-0.60	......	4.00-6.50	0.40-0.65	5 Cr (E502)	500-700 F	Recommended, 1300-1400 F	Same.
Nickel	0.20-0.40	0.50-1.00	0.30-0.60	2.00-3.00	......	......	E7015-C1, E8015-C1, E9015-C1	300-500 F	Optional, 1200-1300 F[6]	After welding cool in still air. Postheat-treatments desirable to reduce hydrogen content and soften heat-affected zone. For carbon content above 0.35% preheating to 400 to 500 F is desirable. Postheat-treatment is desirable to soften heat-affected zone.
	0.15-0.40	0.50-1.00	0.30-0.60	3.00-4.00	......	......	E9015-C2, E10015-C2, E12015-C2	400-600 F	Recommended, 1200-1300 F	For best results castings should be transferred to the heat-treating furnace immediately upon welding. If postheating is not possible, cool weldment slowly under insulation.
Nickel-manganese	0.20-0.40	1.00-1.65	0.30-0.60	1.00-1.50	......	......	E80XX, E90XX, E100XX[4]	200-400 F	Optional, 1100-1250 F[6]	Stress-relieving is desirable where weldments are to be machined.
							E8015, E9015, E10015[5]	Up to 300 F	Optional, 1100-1250 F[6]	Same.
Nickel-manganese-molybdenum	0.20-0.40	1.00-1.35	0.30-0.60	1.00-1.50	......	0.10-0.20	Same recommendations as for Nickel-manganese steel			
Nickel-chromium	0.20-0.40	0.50-1.00	0.30-0.60	1.00-1.50	0.45-0.90	......	E90XX, E100XX[4]	200-400 F	Optional, 1100-1250 F[6]	Same.
							E9015, E10015[5]	Up to 200 F	Optional, 1100-1250 F[6]	Same.
							E12015, E12016[7]	Up to 200 F	Optional, 1100-1250 F[6]	Same.
Nickel-chromium-molybdenum	0.15-0.40	0.50-1.00	0.30-0.60	0.40-0.70	0.40-0.60	0.20-0.65	E70XX, E80XX[4]	200-400 F	Optional, 1150-1250 F[6]	Low-hydrogen EXX15 and EXX16 electrodes are recommended to minimize or prevent underbead cracking.
	0.15-0.40	0.50-1.00	0.30-0.60	0.85-1.15	0.70-1.00	0.30-0.65	E7015, E8015[5]	Up to 200 F	Optional, 1150-1250 F[6]	Same.
							E8015, E9015[5]	300-500 F	Recommended, 1200-1300 F	For best results castings should be transferred to the heat-treating furnace immediately upon welding. If postheating is not possible, cool weldment slowly under insulation.
	0.15-0.40	0.50-1.00	0.30-0.60	1.25-2.00	0.70-1.00	0.30-0.65	E10015, E12015[5]	400-600 F	Recommended, 1200-1300 F	Same.

Nickel-chromium-manganese-molybdenum	0.20-0.40	1.25-1.60	0.30-0.60	1.00-1.30	0.60-0.90	0.30-0.40	E10015, E12015[5]	400-700 F	Recommended, 1250-1350 F	Same.
Nickel-molybdenum	0.20-0.40	0.50-1.00	0.30-0.60	1.25-2.00	......	0.25-0.40	E8015, E9015, E10015[5]	200-400 F	Optional, 1200-1300 F[6]	Stress relieving is desirable where weldments are to be machined.
Nickel-vanadium	0.20-0.40	0.50-1.00	0.30-0.60	1.25-2.00	......	(0.08-0.15V)	E12015, E12016[7]	300-500 F	Recommended, 1200-1300 F	For best results castings should be transferred to the heat-treating furnace immediately upon welding. If postheating is not possible, cool weldment slowly under insulation.
Manganese	0.20-0.40	1.50-2.50	0.30-0.60	......	......	......	E90XX, E100XX[4]	200-400 F	Optional, 1100-1250 F[6]	Stress relieving is desirable where weldments are to be machined. For best results castings should be transferred to the heat-treating furnace immediately upon welding. If postheating is not possible, cool weldment slowly under insulation.
							E9015, E10015[5]	Up to 200 F	Optional, 1100-1250 F[6]	Same.
							E12015, E12016[7]	200-400 F	Recommended, 1100-1250 F	Same.
Manganese-molybdenum	0.20-0.40	1.00-1.35	0.30-0.60	......	......	0.10-0.20	Same recommendations as for Manganese steel			
	0.20-0.40	1.35-1.75	0.30-0.60	......	......	0.30-0.40	Same recommendations as for Manganese steel			
Copper	0.15-0.35	0.50-1.00	0.30-0.60	......	......	(0.75-2.00 Cu)	E80XX, E90XX, E100XX	200-400 F	Optional, 1100-1250 F[6]	Stress relieving is desirable where weldments are to be machined.
							E8015, E9015, E10015[5]	Up to 200 F	Optional, 1100-1250 F[6]	Same.

---

[1] The strength values of the electrodes should correspond to the strength characteristics of the casting. The higher the carbon and alloy content, usually the higher are the strength requirements of the electrode desired.

[2] Stainless-steel electrodes types 29 Cr, 9 Ni (312); 25 Cr, 20 Ni (E310); and 25 Cr, 12 Ni (E309) also have been and are still being used on low-alloy steel castings, particularly in heavy sections where preheating and postheating are difficult. However, the general and better practice is to use the carbon or low-alloy steel EXXXX electrodes recommended in the table.

[3] Use lowest preheat temperature for sections up to ½-inch thick and highest value for sections over 2 inches thick, with intermediate temperatures at intermediate thicknesses. Preheating temperatures should also be higher for carbon and alloy contents in the upper part of the composition range.

[4] Except the low-hydrogen types EXX15 and EXX16.

[5] Also the corresponding EXX16 low-hydrogen electrodes.

[6] Alloy-steel castings with carbon and alloy contents in the upper part of the composition range should be cooled under insulation immediately following welding. When postheat treatments are used, the castings should be transferred to the furnace immediately upon welding and heated for 1 hr per inch of thickness at the indicated temperatures.

[7] For cast steels on the high side of the carbon and alloy range.

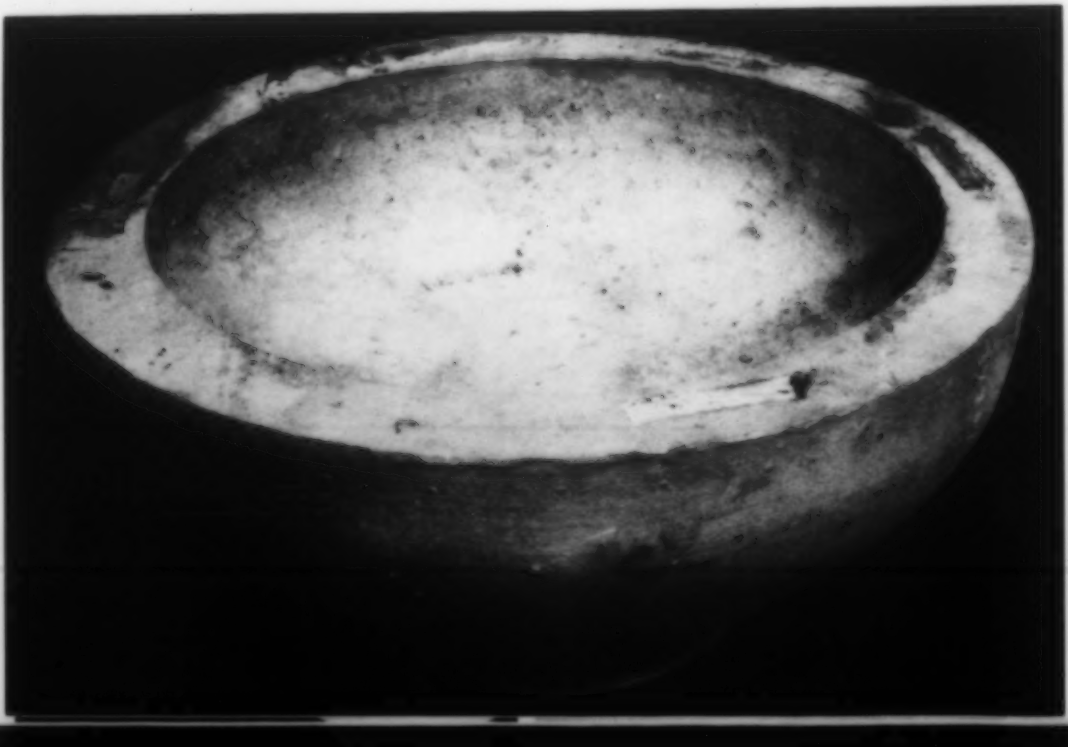
will be recommended, and heat treatments suggested.

Welding Recommendation: Weldability of cast carbon and low-alloy steels is similar to that of comparable wrought-steel grades, with variations depending primarily upon the chemical composition of the steel.

Cast steels generally have higher carbon and silicon contents than the corresponding wought-steel grades. The carbon content for most commercial low-alloy cast steel grades varies between 0.20 and 0.35 per cent. Lower or higher carbon-content grades usually are cast only as special products. For example, several alloy-steel casting grades for valves, flanges, fittings and other pressure-containing parts intended for high-temperature service are specified in ASTM specification A217-49T with a maximum carbon content of 0.20 per cent.

Since electrodes and welding rods used to weld

Fig. 2 — Cast-steel pressure-vessel closure section prior to machining the weld groove



cast steels have a relatively low carbon content (usually 0.08 to 0.12 C), mechanical properties and characteristics of the resulting weld may differ somewhat from those of the base steel. Nevertheless, strengths of low carbon-content weld deposits may approach those of the adjacent cast steel of higher carbon content because of the fine grain size typical of weld deposits. Where carbon content of the cast steel exceeds 0.30 per cent, desired strength values of the weld metal are readily obtained by using electrodes of somewhat higher alloy contents.

Heat treatments of welded sections, such as normalizing or quenching and tempering, may be used to obtain more uniform properties in the cast steel, the heat-affected zone, and the weld metal. Special alloy-steel electrodes are available which deposit weld metal responding to heat treatment in a similar manner as the cast steel.

Typical recommendations for arc welding of the more common carbon and alloy-steel casting grades are given in *Table* 1.

Heat Treatment: Although carbon-steel castings with less than 0.30 per cent carbon may not always require preheating and maintenance of a minimum interpass temperature, preheating to 200 or 300 F may be advisable where the sections are large and complicated. For the higher-carbon and alloy-steel grades, preheat and interpass temperatures between 400 and 600 F and higher may be necessary. The higher temperatures in this range should be used for grades with higher carbon and/or alloy content and for sections of increasing wall thickness.

In steel castings of varying section thicknesses, welds on heavy sections will cool more rapidly than on thin sections. Since this may result in severe residual stresses, and cracking in extreme cases, higher preheating temperature should be used than for castings of more uniform dimensions. During welding the castings should be protected from drafts, which may cause excessively rapid and uneven local cooling.

Where recommended preheat temperatures are below 400 F with ordinary electrodes, the preheat and interpass temperatures required may be reduced by about 200 F by using appropriate low-hydrogen EXX15 or EXX16 electrodes. For preheat and interpass temperature requirements above 400 F the same temperatures should be used with low-hydrogen as with the other electrode types.

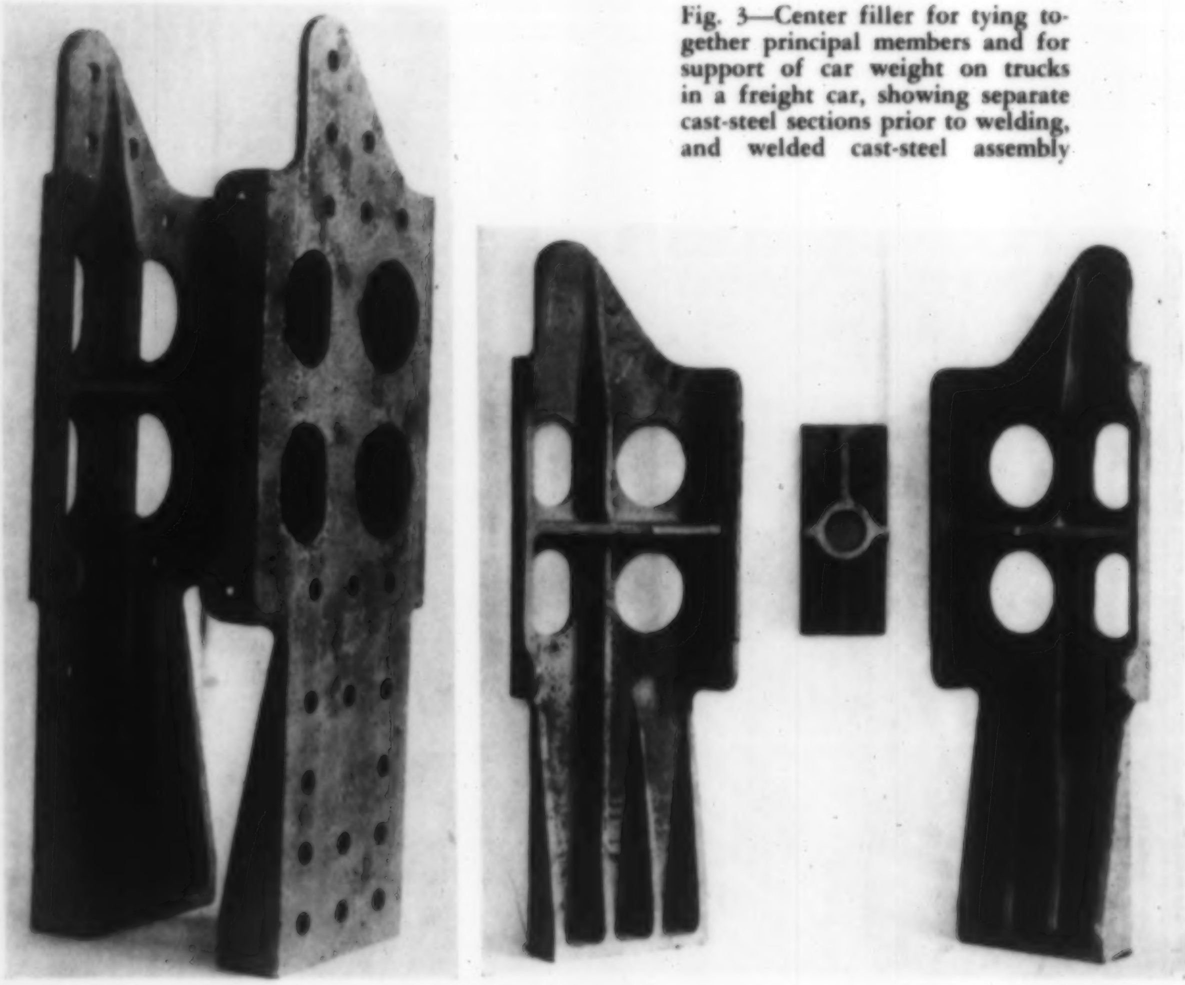


Fig. 3—Center filler for tying together principal members and for support of car weight on trucks in a freight car, showing separate cast-steel sections prior to welding, and welded cast-steel assembly

After welding, the welded areas should be slowly cooled under asbestos covering or sand. Where postheat treatments are recommended, they should be made in a furnace and preferably immediately upon completion of the welding operation. Postheating by other heating methods, such as induction heating, which heat the welded area uniformly may also be satisfactory.

Stainless-Steel Electrodes: Austenitic stainless-steel electrodes types E310 (25 Cr, 20 Ni), E309 (25 Cr, 12 Ni) and E312 (29 Cr, 9 Ni) also have been used (and are still being used) to weld low-alloy steel castings, particularly in the repair of casting defects found by inspection in the foundry and cracks which have occurred in service. With the commercial development of low-hydrogen electrodes, this practice is neither necessary nor advisable.

A number of service failures can be ascribed to austentic stainless-steel weld deposits on low-alloy cast steels. Such failures are particularly common on cast steels exposed to service temperatures above 800 F. For example, cast-steel valve or fitting bodies used in high-temperature steam piping systems may occasionally contain casting defects, such as excessive shrinkage or porosity. It is perfectly good practice to cut out, chip out or gouge out the defective area and repair the area by welding, provided that a proper electrode has been used. The resulting repair-welded casting would be just as sound structurally as the original casting.

However, where repairs have been made with stainless-steel electrodes, service exposure above 800 F causes a gradual change in the "dissimilar" metallurgical structure. This change weakens the affected area and, in time, may result in a failure across the joint. Such dissimilar welds can be extremely critical even in very small deposits. In *Fig.* 5, for example, the small black area represents a stainless-steel deposit between a carbon-molybdenum weld deposit to a carbon-molybdenum pipe section. After some 12 years of service at 950 F, the carbon-molybdenum steel area adjacent to the stainless-steel weld became decarburized and embrittled. Bend tests across this area showed initial cracking upon bending to 5 degrees with a bend elongation of 2 per cent in ½-inch.

Gas Welding: Gas welding of cast steels in thin sections requires considerations similar to those of the corresponding wrought grades. The required preheat temperatures can usually be provided by torch manipulation. For sections over ½-inch thick, local or even complete preheating might be necessary. Since the high degree of preheat required would be of considerable discomfort to the welder, arc welding is usually preferred over gas welding. In arc welding the welder can protect himself better from the heat, and can proceed at greater speeds.

PHOTO CREDITS

Photographs in *Figs.* 1 through 4 have been supplied by courtesy of Steel Founders' Society of America.

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This article is the third in a co-ordinated group of articles by Helmut Thielsch on welding and weldments. Previous articles, and issues of MACHINE DESIGN in which they appeared, are:

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Weldability of Stainless Steel	June, 1955

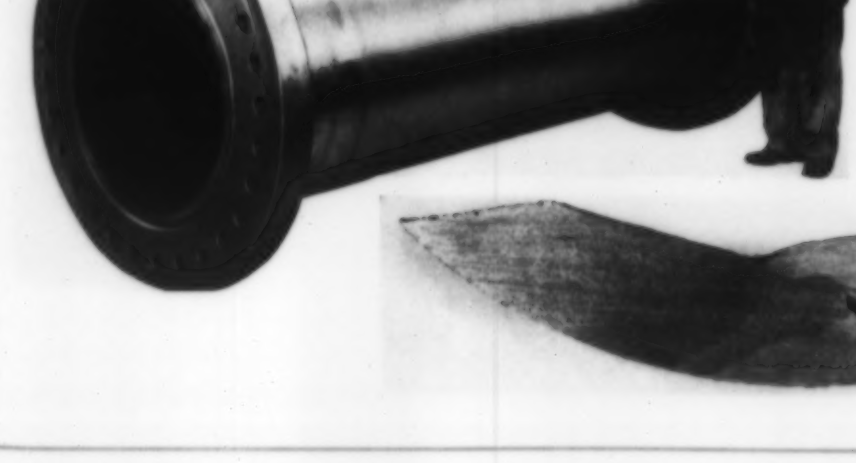
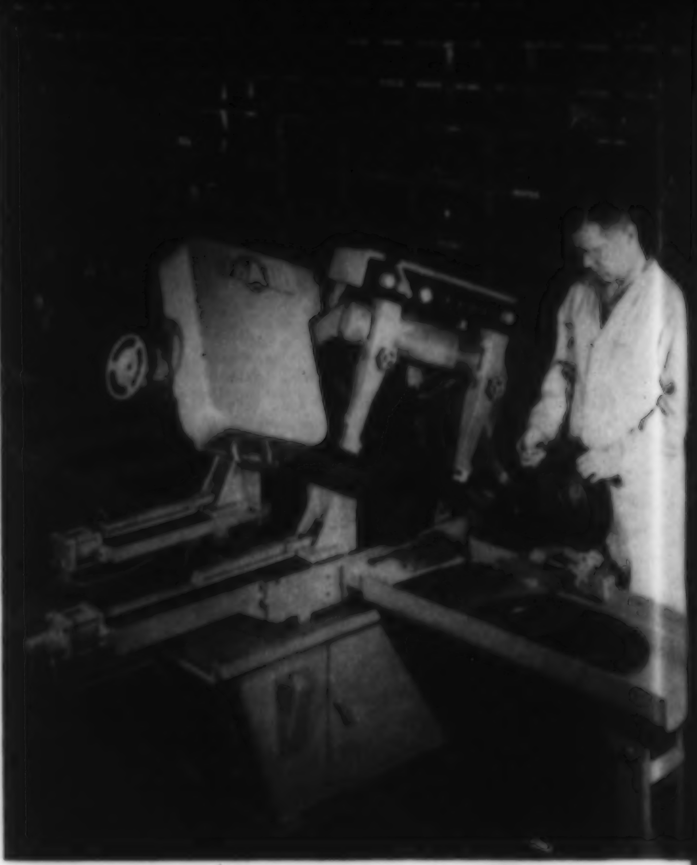


Fig. 4—Left—Five-ton hydraulic cylinder produced by welding a cast-steel cylinder to cast-steel flange sections

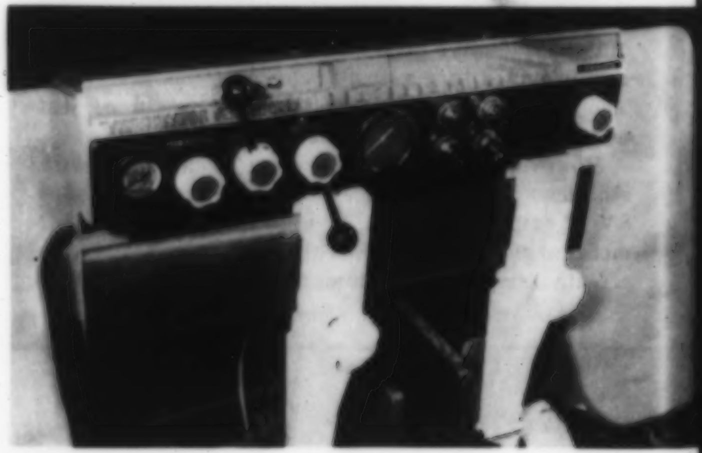
Fig. 5 — Below — Stainless-steel weld repair between carbon-molybdenum cast-steel valve body and carbon-molybdenum steel weld deposit

Saw Has Automatic Hydraulic Adjustments

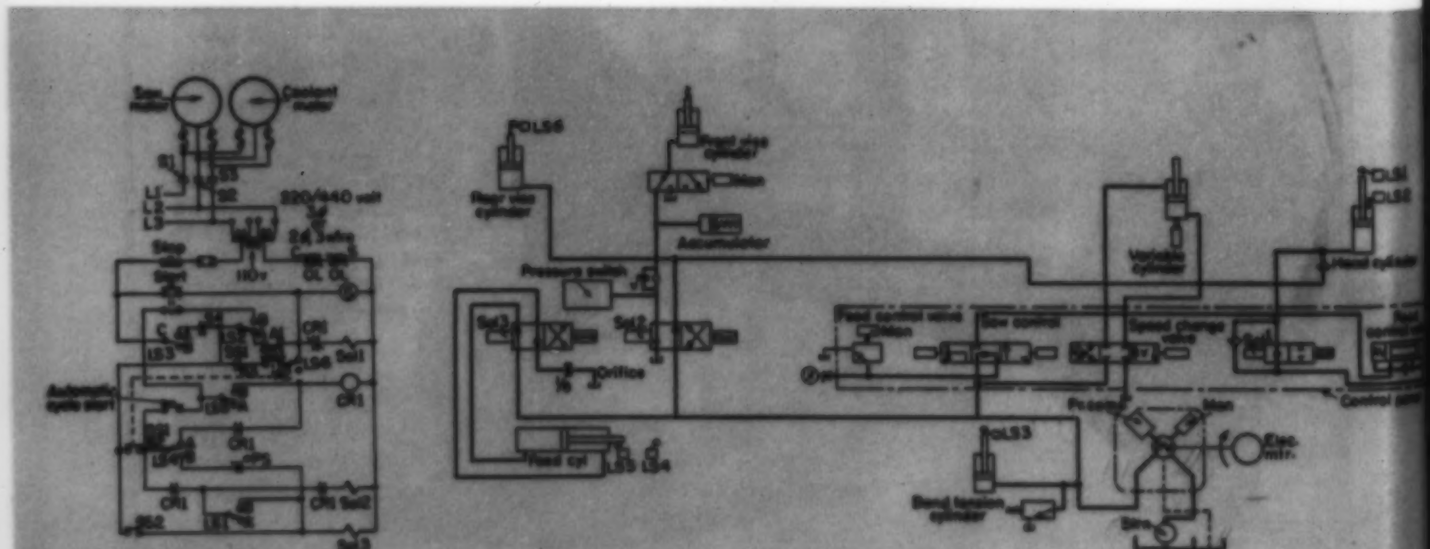
A RECENTLY introduced, metal-cutoff bandsaw has such features as automatic cycling, automatic feed control, variable speed control and a hydraulic band-tensioning system to maintain constant cutting-blade pressure. Designed to use new, narrower, high-speed steel bands, the Do-All saw is said to cut fast and accurately while producing little waste material because of its narrower cut.



All controls are in a panel mounted on the saw head. Controls and gages, from left to right, are: feed-pressure gage; feed-pressure control; saw-speed control; saw-speed indicator calibrated in sfpm; pushbutton switches for starting, stopping and selecting automatic or manual cycling; and the coolant flow control. At the top of the control panel is a calculator which indicates correct feed and speed when material type, blade type and work thickness are set.



Circuit diagrams of electrical and hydraulic systems show the method of operation for both manual and automatic control. With the selector switch, *SS* 1, set for manual operation, contact *A*1 is closed. Pressing the start button then energizes relay coil *S* whose contacts close to start the coolant motor and saw motor which also drives the hydraulic pump. Contacts of *S* are held in through *LS* 3, *S*4, *LS* 2 and the *A*1 con-

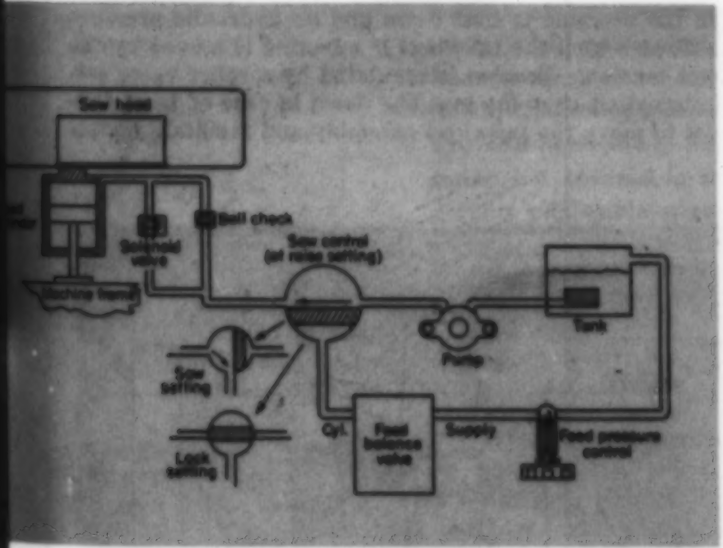

Saw motor
Coolant motor
S1
S3
S2
L1
L2
L3
220/440 volt 3φ 60 cy
24 3-wire
Stop
Start
110v
OL OL
C
LS3
LS2
CR1
Sol1
LS6
CR1
Automatic cycle start
LS2
CR1
LS4
CR1
CR1 Sol2
SS2
LS1
Sol3
LS6
Rear vise cylinder
Front vise cylinder
Man
Accumulator
Pressure switch
Sol3
Sol2
Orifice
Feed cyl
LS3 LS4
Feed control valve
Man
Saw control
Speed change valve
Variable cylinder
LS1
LS2
Head cylinder
Sol1
Control panel
Pressure
Man
LS3
Elec mtr.
Band tension cylinder
Strn

tacts of *SS* 1 since *LS* 3 moves to the *A* position as soon as the pump supplies adequate pressure to properly tension the saw blade and *LS* 2 is held at *A* when the head cylinder is up. Solenoid 1 is energized through the normally closed *CR* 1 contacts, opening the hydraulic feed to the head cylinder. When the saw has cut through the workpiece, *LS* 2 is actuated, opening the holding circuit of coil *S* and stopping the machine.

For completely automatic operation the selector switch is set to *automatic*. This closes contacts *A*2 and *B*2 and opens *A*1. Pressing the start button energizes coil *S* to start the two drive motors. Hold-in is through *LS* 3 connected to *A*, contacts *A*2 and *A*3 of *SS* 1 and *LS* 6 which is a safety limit switch to break the circuit if there is no stock in the rear vise or if it is improperly adjusted. The automatic cycle start button is then pressed. Should the saw head be down, *LS* 2 will be at position *B* and initiate the automatic cycle through the normally-closed contacts of the start button, and *LS* 5 which will be in the *B* position when the feed cylinder is fully retracted, as shown. This energizes *CR* 1 which is then held by its contact in series with *LS* 4 which is, as shown, in its nonoperated position. *CR* 1 also deenergizes solenoid 1 to block the hydraulic circuit between the head cylinder and the feed control valve. At the same time *CR* 1 energizes solenoid 2 to direct pressure to the head cylinder and raise the head.

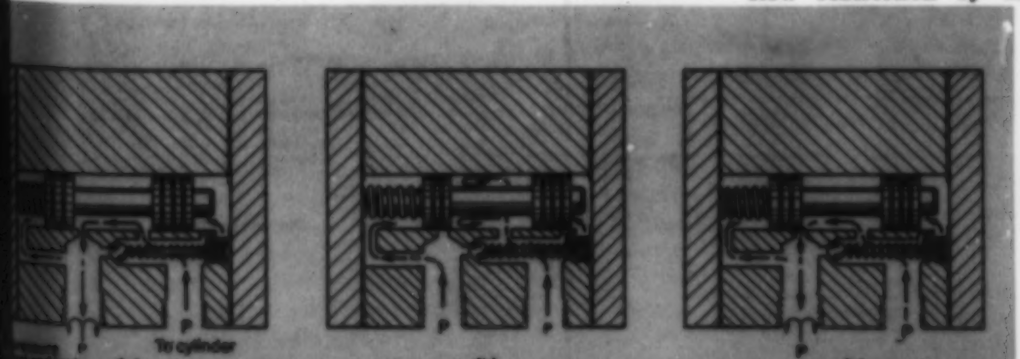
Solenoid 2 also directs pressure to the rear index vise and unloads the front vise. When the saw head reaches correct height as set by an adjustable work stop, *LS* 1 completes the circuit through *B* to energize solenoid 3 and direct pressure to the index feed cylinder, with forward movement of rear vise and work piece resulting. At the completion of the feed stroke, *LS* 4 moves to position *B*, de-energizing *CR* 1 and solenoid 2 to open the rear indexing vise and close the front vise. When pressure on the front vise reaches the setting of the pressure switch, *PS*, the contacts open, de-energizing solenoid 3 and causing the indexing cylinder to retract and reset *LS* 5.

Relay *CR* 1 and solenoid 2 are de-energized at the end of the index stroke by *LS* 4. Solenoid 1 is then energized by the normally-closed *CR* 1 contact to initiate downward feed of the cutting head. Upon completion of the cut, *LS* 2 is actuated and the cycle repeats.



A feed-balance valve is used to maintain the correct feed pressure automatically during all portions of the cut. Actual feeding force is developed by the weight of the saw head and the feed-balance valve cancels out or balances the desired portion of this weight by controlling the rate at which oil is forced from the head cylinder by the weight of the head. The feed pressure control is manually adjusted for the required feed rate.

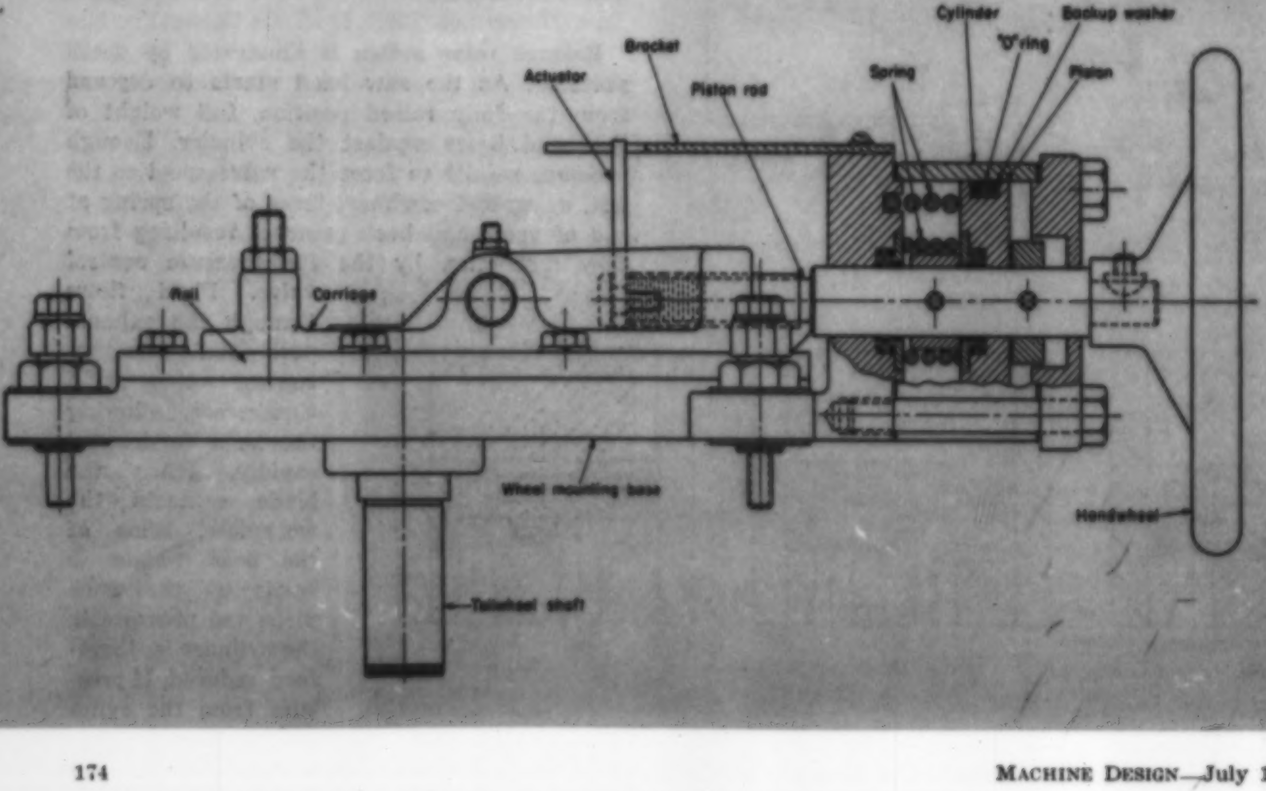
Balance valve action is illustrated by detail sketches. As the saw head starts to descend from the fully raised position, full weight of the head bears against the cylinder. Enough pressure results to force the valve spool to the left, *a*, against combined force of the spring at end of spool and back pressure resulting from flow restriction by the feed-pressure control valve. Fluid flows through the exhaust port and pressure-control valve at a rapid rate, allowing the head to descend rapidly. When the blade contacts the workpiece, some of the head weight is borne by the work piece and pressure in the cylinder is, therefore, reduced. If pressure from the cylin-



der drops below combined spool spring and control-valve back pressure, spool will tend to move to the right, close the exhaust port and stop descent of the head, *b*. Pressure on the valve spool thus equalizes at some degree of valve port opening, *c*, to give a steady controlled feed rate.

Blade speed is varied from 90 to 350 sfpm, as required, by a control valve mounted on the panel, a small hydraulic cylinder and a floating-sheave transmission. Mounted on a rocker arm, which is rotated by the hydraulic cylinder in response to control-valve setting, the transmission sheaves vary in pitch to produce speed changes as the arm rotates. Blade speed is indicated by a tachometer on the control panel. When correct speed is set, the control valve is turned to a hold position.

Blade tension is preset at the factory and controlled automatically by a hydraulic cylinder. A spring within the cylinder maintains enough tension to keep the blade in position when the machine is shut down and no hydraulic pressure is available. The stub shaft on which the tailwheel is mounted is moved by the cylinder to maintain correct tension. Tension is regulated by a relief valve setting. An actuator and limit switch shut the machine down in case of band failure. The handwheel is used to move the tailwheel assembly and facilitate installation of a new blade.



By Robert C. Rodgers, *Associate Editor, Machine Design*

Factors in Selecting Magnetic Slip Couplings *for Adjustable-Speed Service*

Many types of adjustable-speed drives are available, each with its own characteristic advantages and disadvantages. As an aid to selection, design and application in this field, *Machine Design* is presenting a group of comprehensive articles on each of the major drive systems. Characteristics of adjustable-speed electric-motor drives were covered in October 1954, mechanical adjustable-speed drives in April and June 1955. Another answer to adjustable speed is the magnetic slip coupling or clutch. Operating principles and details, speed and torque characteristics, size and horsepower limitations, and typical areas and methods of application are covered in this article. A *Machine Design* staff report on hydraulic adjustable-speed drives will be presented in a future issue.

ALTHOUGH many electric or magnetic slip couplings are used primarily as clutches and brakes, these units are finding more and more applications in adjustable-speed service. The reason is that most such coupling devices are rugged, easy to maintain, and simple to control. Typical couplings and drives are illustrated in *Figs.* 1 to 4. Also, initial cost of the various types of units is favorable with many other types of adjustable-speed drives, especially so where speed ranges are not too wide and torque values are such that heat dissipation within the coupling is not too great.

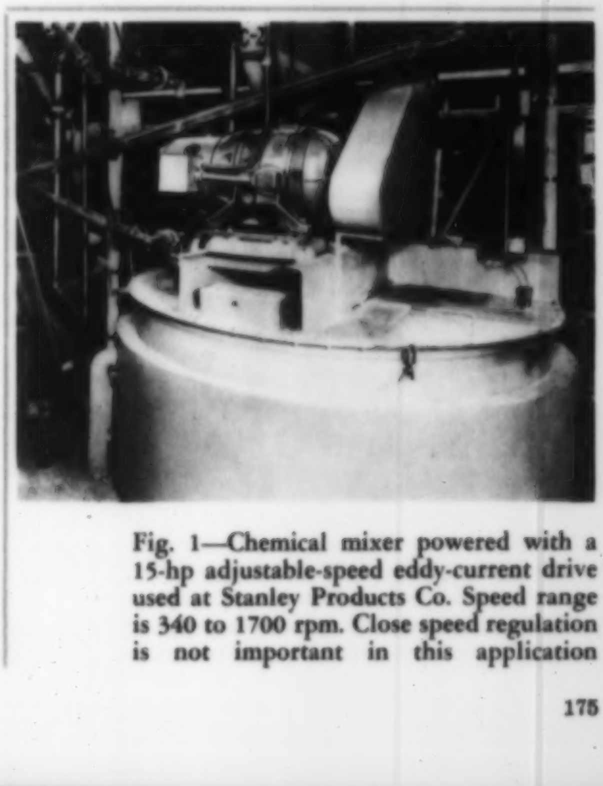


Fig. 1—Chemical mixer powered with a 15-hp adjustable-speed eddy-current drive used at Stanley Products Co. Speed range is 340 to 1700 rpm. Close speed regulation is not important in this application

Several electromagnetic coupling designs have been developed and are finding wide application in many areas of design. Discussed in this article are eddy-current, hysteresis, magnetic-particle and magnetic-fluid types of units. Each basic type exhibits advantages for certain areas of service but limitations and drawbacks are apparent, too. Basically, electric slip couplings transmit torque at various rotational speeds from standstill up to synchronous speed of the input shaft on some types and at slightly less than synchronous on others. The devices covered in this article are all torque transmitters but cannot multiply torque.

One obvious advantage of a combination clutch and adjustable-speed transmission is that a motor or engine may be started and brought up to normal operating speed under no load. Then through an electromagnetic coupling, created by one of several means which will be described, the connected load may be brought up either to slightly less than, or to the speed, of the prime mover along a straight or curved time versus speed line. Thus, for example, an electric motor can reach normal operating speed before it is coupled to the load. Application of the load with the motor running at rated speed means that duration of current inrush is much less than it would be if the motor were started from standstill under load. Thus the motor heats up less if starts are frequent, and sometimes this feature permits the use of smaller motors and smaller capacity starting equipment.

Eddy-Current Couplings and Drives

In many rotating electrical machines eddy currents are considered detrimental to machine efficiency. Therefore, designers of motors and generators often go to great pains to design-out eddy currents. However, in eddy-current couplings these currents are effectively harnessed to do work. These units are basically nonfrictional couplings operating through the medium of a simple magnetic field. When an eddy-current coupling is connected directly to either a synchronous or an induction motor, the result is an adjustable-speed drive. Regardless of the type of load to be driven, any prime mover selected can be connected to an eddy-current coupling and can be brought up to speed before the load is applied. This is desirable in most drives especially for synchronous and induction motors. The load can be released at any time and, in the case of synchronous motors, power factor correction can be enjoyed.

Operating Principles: An eddy-current coupling consists of essentially two parts, one coupled to a rotating power input shaft and the other to the shaft of a driven machine. These two parts, a field and a drum, are separated by an air gap. There is no mechanical contact between driven and driving members. When the field assembly (magnets and coil) is mechanically rotated, the iron ring surrounding it remains stationary until current is applied to the coil. With the coil energized, relative motion between the magnet poles and the ring creates eddy currents in the ring, *Fig.* 5. These

Fig. 2—Yoder slitter with 50-hp, 1700-rpm eddy-current drive used to pull sheet metal through cutters and wind strips on reels. A 4 to 1 speed range on reels is required to maintain constant linear speed on metal. Smaller adjustable-speed unit in foreground drives scrap wind-up

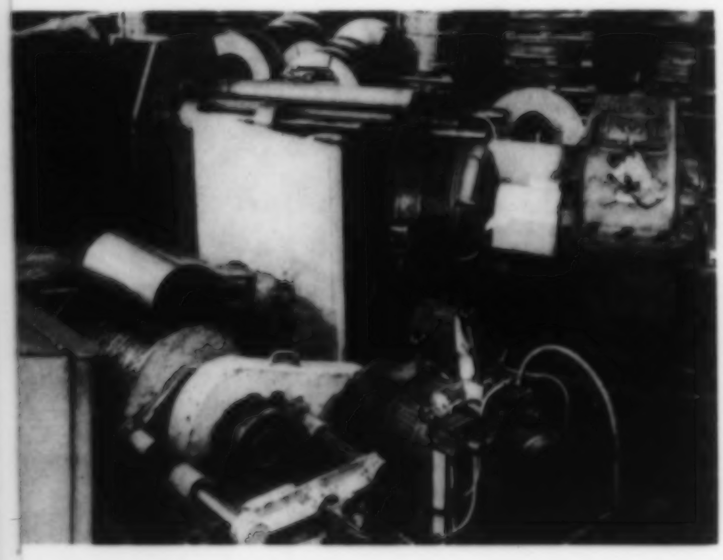


Fig. 3—Wire-winding machine employing magnetic-particle clutches and brakes for speed and tension control

induced currents produce a second magnetic field. The strength of this magnetic field in the ring is determined by (1) the strength of the rotating electromagnetic field and (2) the difference in speed between the two members. Attraction of these two fields causes the ring or drum member to follow the rotating field.

Direct-current excitation is applied to rotating magnet field windings through collector rings on some types such as the fractional-horsepower, air-cooled unit shown in *Fig.* 6. Slip rings are eliminated in units having the field stationary such as illustrated in the liquid-cooled coupling shown in *Fig.* 7. Controlling slip between input and output produces control of both speed and torque. Slip is determined by the amount of field excitation. Since the eddy-current coupling must slip some (usually 1½ to 5 per cent minimum) to develop appreciable torque, it cannot be used as a clutch in the usual meaning of the word unless this slight amount of slippage can be tolerated.

Torque and Speed: Generation of sufficient torque and dissipation of the heat developed are two basic problems of prime importance in the design of rotating electrical machinery. An eddy-current coupling develops a rated value of torque at a specified slip speed and amount of excitation. To prevent stalling in the event of momentary overload, these units will develop sufficient peak torque. Of course, accelerating torque of the unit is nor-

Fig. 4—Small magnetic-powder clutch. Typical application is in automatic pilots to control roll, pitch and yaw

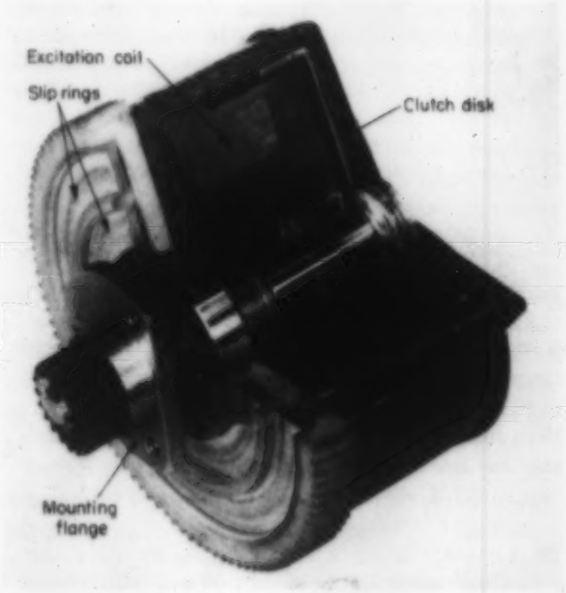
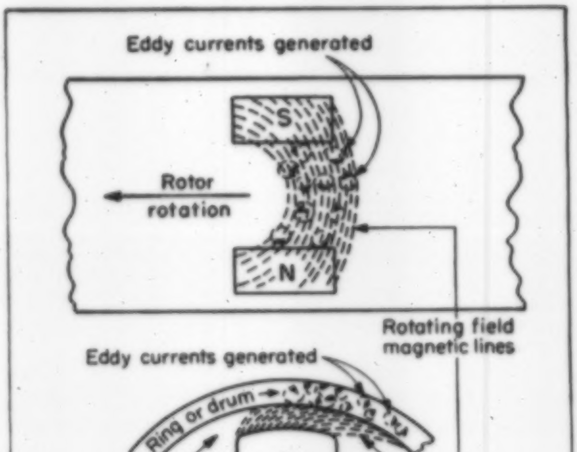
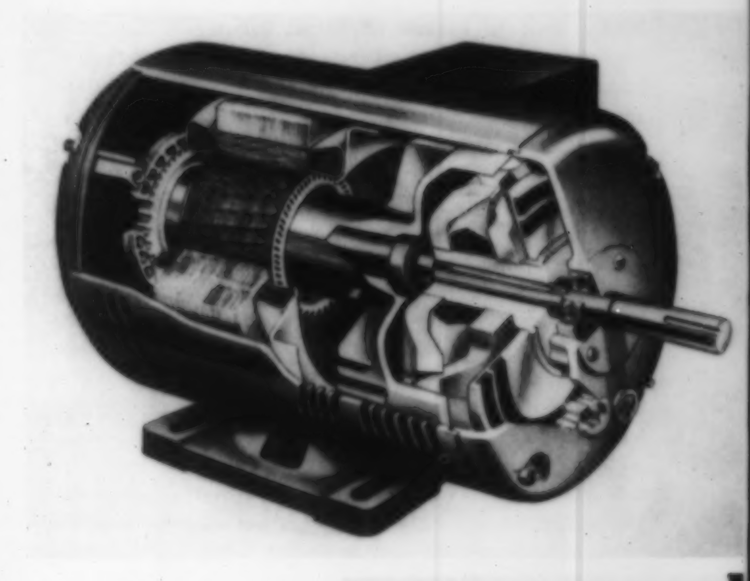


Fig. 5—Eddy-current field generated in driven ring of eddy-current coupling when field assembly (magnets and coil) is mechanically rotated





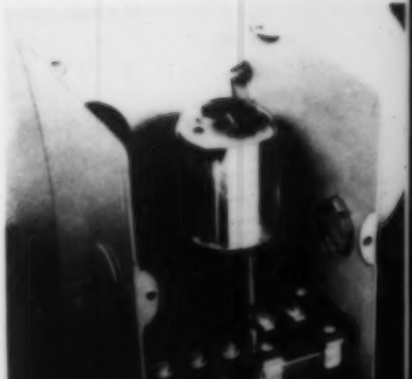


Fig. 6 — Fractional-horsepower drive with integral combination ac motor and adjustable-speed eddy-current clutch. Single thyratron tube supplies dc excitation to clutch field for speed control

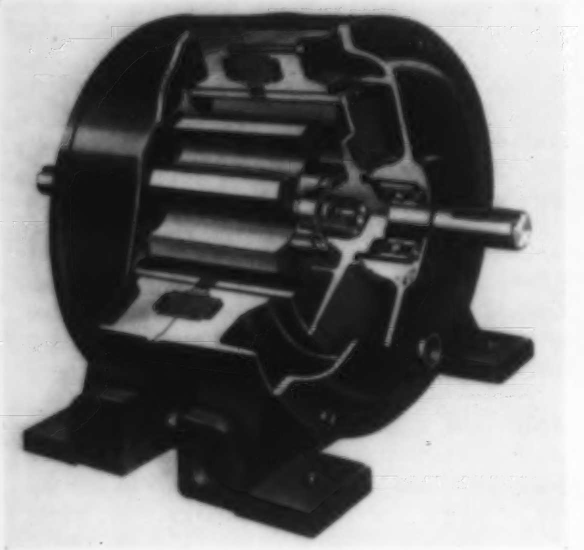


Fig. 7 — Stationary-field, liquid-cooled, adjustable-speed, eddy-current coupling. Units range in size from 1 to 1500 hp

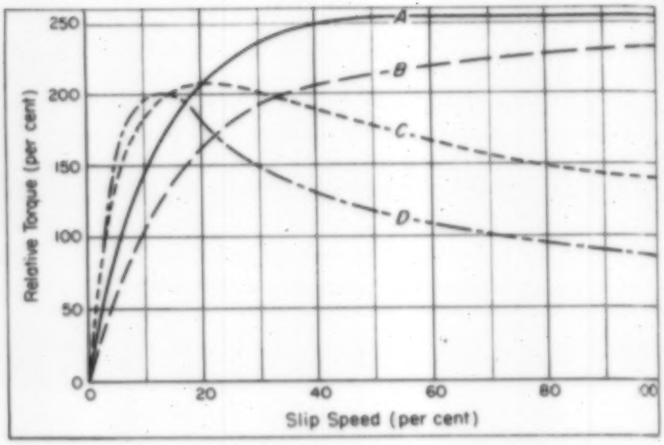


Fig. 8—Typical torque versus slip curves obtainable by different pole-shape designs in eddy-current couplings. Curve *A* represents stationary-field type of construction; *B* is single rotating circumferential coil and cast field ring with projection; *C* is an ideal curve; *D* is salient-pole construction

mally well in excess of rated torque.

The same factors which affect the speed-torque characteristics of an induction motor are prevalent in an eddy-current coupling. However, eddy-current drives differ from induction motors in that the cast field poles such as shown in the fractional-horsepower unit in *Fig.* 6 allow wide variations in pole shape. Effects of different pole shapes on speed-torque characteristics are shown in *Fig.* 8. Torque and load curves for a typical eddy-current coupling for various degrees of excitation are shown in *Fig.* 9. Excess torque, which is a measure of accelerating capacity, is indicated in *Fig.* 9 for constant-torque and variable-torque (fan) loads.

Efficiency: Eddy-current coupling efficiency compares almost directly with the wound-rotor induction motor over the entire speed range. Slip losses in both units are identical and torque transmitted through either the coupling or motor is the same at all lower speeds. Obviously, power coming from either machine is proportional to output speed. At 50 per cent output speed, output power is approximately 50 per cent of the input. However, efficiency values as high as 95 to 97 per cent at full speed and torque are possible in the larger sizes. In many adjustable-speed applications, the machine is driven most of the time near top speed where coupling efficiency is relatively high. Water-in-the-gap cooled units are quite efficient at full speed, because the coolant flowing in the gap produces some added torque. An efficiency of better than 96 per cent has been measured on large units.

Bearing losses are comparable to similar size machines and excitation power losses are low relative to the power transmitted. On air-cooled couplings windage loss may be 3 to 5 per cent depending on speed and application.

Where input-output efficiency is particularly important or heat losses are objectionable, drives with multispeed electric motors can be specified.

Heat Losses: Being a slip device, an eddy-current coupling must of necessity reject slip power loss in the form of heat. The amount of slip loss at any speed and load point may be determined from

$$P_s = P_L \frac{N_s}{N_o}$$

where P_S = slip loss power, hp; P_L = load power, hp; N_S = slip speed, rpm; and N_O = output speed, rpm.

With a constant-torque load, slip losses are directly proportional to speed reduction. If torque is reduced, slip losses decrease proportionately. On a fan load, maximum slip loss occurs at 2/3 rated speed and the amount of slip loss is approximately 15 per cent of rated horsepower capacity of the units.

Cooling: The generation of torque in slip devices is always accompanied by liberation of heat. The eddy currents which develop the torque in the coupling flow very near to the surface of the inductor drum. Coupling units employed in eddy-current drives are either air cooled, *Fig.* 6, or water cooled, *Fig.* 7. Air versus liquid-cooled units are selected on the basis of the amount of heat to be dissipated. Water-cooled units are designed to dissipate continuously all the horsepower that the coupling could normally transmit. The water-cooled units show a slight efficiency advantage over air-cooled units and are extremely quiet. Water-cooled couplings are usually preferred over air-cooled types except where low slip losses are normally encountered or piping of water is undesirable or impossible.

The required amount of cooling water for any application assuming the outlet water temperature is limited to 160 degrees is given by the formula

$$Q = \frac{P_s}{0.196\ (160 - T_i)}$$

where Q = flow rate, gpm; P_S = slip loss power, hp; and T_i = inlet water temperature, F.

Water-cooled couplings are designed with sufficient heat rejection capacity to handle the full motor rating continuously. Thus the coupling could continuously develop rated torque from zero to full speed at the output shaft.

The problem of heat dissipation is more severe in the air-cooled coupling, of course. Smaller units —¾ to about 5 hp—can usually be designed to dissipate all of their rated power. The relative amount of heat rejection decreases as the size of the eddy-current coupling increases. In fact units in the 200 to 300-hp sizes can only dissipate 20 or 25 per rated capacity and remain within limits of design economy. On fan and centrifugal-pump loads this dissipation capacity is sufficient, but on constant-torque applications the larger air-cooled types are usually not recommended where heat rejection would need to exceed 20 per cent.

Although it may depend on the particular application, the water-cooled types are usually recommended where water availability presents no serious problems.

Excitation and Control: The energy required for field excitation of eddy-current coupling devices (clutches or brakes) is relatively small but not necessarily in proportion to power transmission capacity. For example, a 50-watt control rectifier will handle couplings to 3-hp capacities at 1800 rpm whereas a 12,000 hp, 500-rpm unit requires a 20-kilowatt capacity field control. However, the low percentage of power needed for excitation in comparison to that being coupled or driven often permits these units to offer an advantage from the standpoint of original cost and maintenance costs on control equipment. Eddy-current drives are readily adaptable to electronic or magnetic-amplifier methods of control to obtain close speed regulation. Such equipment can provide smooth, accurate and automatic speed regulation. Speed can be controlled within 1 per cent over a load change of 10 to 100 per cent. In special applications speed regulation has been held to within 0.1 per cent.

Although this type of slip coupling does not have an inherent constant-speed characteristic except

Fig. 9—Typical eddy-current coupling torque versus output speed curves for three amounts of excitation. Differential torque between excitation curves for constant-torque and fan loads is a measure of acceleration capacity

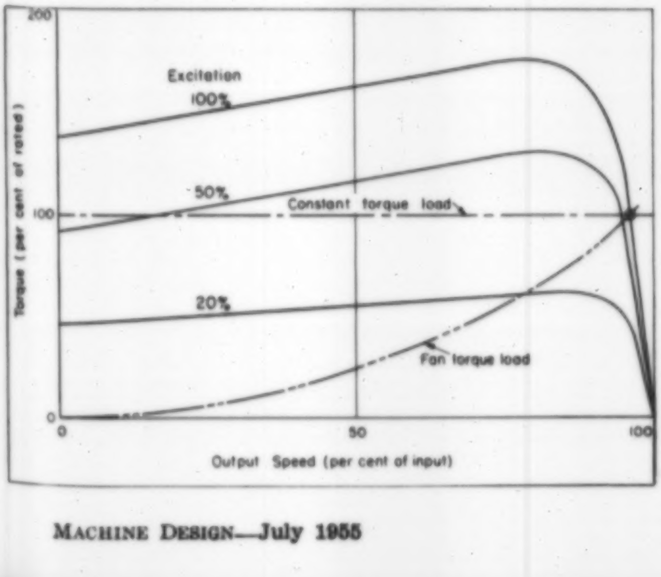
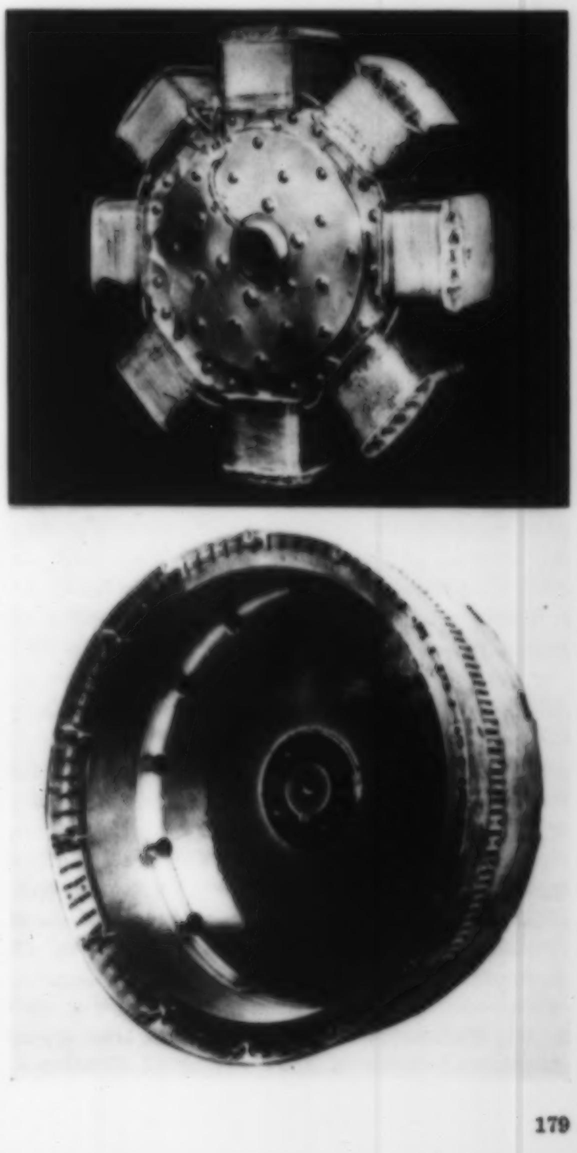


Fig. 10—Salient-pole magnet member and ring member of a typical magnetic coupling. Ducts on surface provide rapid cooling



near full excitation, speed can be controlled over a wide speed and load range. Control is effective, subject to normal limitations in regard to accuracy, from standstill to full operating speed. By modulating the normal amount of excitation, any speed point within the perimeter of the 100 per cent excitation torque curve may be maintained continuously with tachometer-generator control.

Auxiliaries: "Inching" and "jogging" features are available in the eddy-current drives. A control rheostat can be inserted in the circuit to provide prolonged inching (threading) speed control. This may be especially useful if the operator needs to leave his station after pressing the "thread" button.

Another control feature that may be added is a torque limit. It is often advantageous to limit torque to about 25 per cent overload not only to prevent equipment breakage due to stresses set up when the machine jams or locks, but to prevent the operator from exceeding the rating of the equipment.

For rapid reversal of rotation of the load, two couplings may be used, with one connected to the load through a reverse gear. The two couplings are never energized simultaneously. Selection of direction of rotation is accomplished through selective energizing of either coupling. Sometimes two prime movers rotating in opposite directions and two clutches may be the best answer.

Load Considerations: On centrifugal-pump or fan loads, input torque to a machine varies as the square of speed and horsepower varies as the cube of speed. Slip losses on fan loads are limited to about 15 per cent of full speed rating because transmitted power drops much more rapidly than speed. Since air-cooled units have at least a 20 per cent dissipation capacity even in the larger sizes, variable-torque fan type loads can be easily handled by eddy-current couplings.

In constant-horsepower loads, as represented by machine tool applications, torque varies inversely with speed over a limited range. Size and range of speed adjustment determine the feasibility of an eddy-current drive. A dc motor drive with field weakening speed control can most effectively handle the type of load power requirement over a wide range. However, for narrow speed ranges—2 to 1 or less—eddy-current drives compare favorably with dc shunt motor drive systems in initial cost in the larger horsepower sizes—100 to 500.

While changing from one speed to another, most processing machines require a constant torque input. Eddy-current drives and dc shunt motor drives are ideal for such service. For constant-torque loads, a water-cooled eddy-current coupling is usually recommended. Here, too, efficiency, maintenance expense, reliability, and initial cost are important.

Eddy-current drives are often used for press drives. Maintenance can be high on this type of equipment because of high torsional stresses imposed on the press parts and friction clutch wear. Use of an eddy-current drive results in higher output speeds because of reduced shock on starting, and less noise, especially on small machines where cycling is rapid and the number of machines within an area is large.

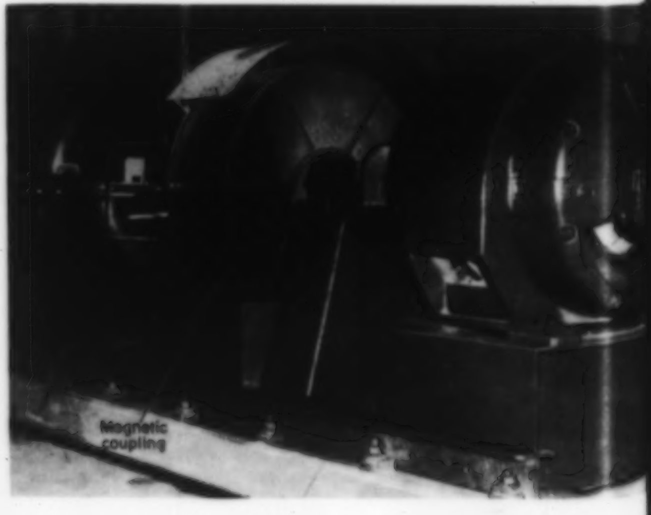
Damping Characteristics: When transmitting power, the eddy-current coupling acts as an untuned damper. Because of this inherent characteristic, oscillatory or torsional vibration cannot be transferred from driving to driven member or vice versa. Sometimes this is a distinct advantage over any friction lockup type of clutch. Because of the slip characteristics of the unit, there is no tendency to oscillate toward a synchronous point.

In prime movers that have torsional vibrations, as is somewhat characteristic of reciprocating engines, an eddy-current coupling will attenuate these pulsations so that they are unnoticeable. Slip couplings are well adapted for ship propulsion where cushioning of engine vibration and power pulses contribute to smoother riding by preventing these pulses from entering the propeller shaft.

Application and Selection Factors: Initial cost and maintenance expense are prime considerations in the selection of any drive. Likewise, efficiency along with accuracy and ease of control often enter the picture. The relative importance of these and other points will vary from application to application.

In comparing eddy-current couplings with some mechanical adjustable-speed drives, such as a variable-pitch pulley unit, the coupling will generally have a higher initial cost. However, time required to make a speed change is usually longer and less

Fig. 11—Centrifugal fan pump at Hudson Pulp and Paper Co. driven by a synchronous motor and a 200-hp capacity magnetic coupling with a 154 to 514-rpm speed range



accurate on most mechanical speed changers.

Horsepower Sizes: Integral combinations of an ac induction motor, an air-cooled eddy-current coupling, and a single-tube electronic control are available in the ¼ to ¾-hp sizes, *Fig.* 6. Horsepower ratings on these units are given at 1600 and 3200 rpm and are available to operate on either 115 or 220-volts single-phase ac and 220 or 440-volts three-phase ac. Larger sizes of air-cooled motor-coupling combinations are available with capacities ranging from ¾-hp at 1100 rpm to 75 hp at 1700 rpm. Typical applications of these eddy-current drives are shown in *Figs.* 1 and 2. Available controls for these units range from simple clutch action in which a manually adjusted amount of current is fed to the field coil to a precise electronic control which will maintain a set speed within close limits.

Air-cooled adjustable-speed couplings are available in a wide variety of standard sizes from 1 to 900 horsepower. Large units are practical for fan duty.

Liquid-cooled couplings can be supplied in sizes from 7½ to 18,000 hp. A typical stationary-field liquid-cooled coupling is shown in *Fig.* 7. Usually water taken directly from a city water supply is a satisfactory coolant. In general, water-cooled types are normally somewhat smaller than an electric motor having a horsepower capacity equal to the dissipation capacity of the coupling.

Salient-Pole Magnetic Couplings

Another type of eddy-current or magnetic induction coupling which develops relatively high torque at low slip speeds has a salient-pole type of construction. As with the eddy-current couplings previously discussed, these units depend on magnetic forces of attraction and repulsion to produce drag or slip between input and output. The field is usually direct-current excited and is magnetic-amplifier controlled in many applications. The secondary member is short circuited on itself and carries currents induced by slipping through the primary field. The secondary is made of solid iron, and torque is produced by eddy currents. In some of the larger sizes the secondary may have a double squirrel-cage construction. Construction details of the rotating field and drum in a typical coupling are shown in *Fig.* 10. These drives have full-load speeds ranging from 400 to 1800 rpm. Their output speeds may be adjusted from about 97 per cent of the driving motor speed to about 30 per cent. Most units produced have been in power sizes ranging from 50 to 1250 hp.

Salient-pole magnetic induction couplings are ideal for applications such as fan loads (*Fig.* 11), centrifugal pumps and compressors, etc. On fan-duty loads, the load horsepower varies as the cube of speed. Slip loss in these drives reaches a maximum of about 15 per cent of full load rating at two-thirds speed on fan duty loads.

These units have also found application as drive couplings for ship propulsion. Here they offer the advantage of acting as a vibration damper by preventing torsional vibration originating in the engine from being transmitted to the propeller shaft. Such couplings allow operation of the propeller shaft at speeds below the minimum engine speed. Other applications include paper machines, reels, superchargers, etc.

Hysteresis Clutches

The hysteresis clutch is simple in construction and consists typically of a high hysteresis, hard steel disk located in the field of a power-driven permanent magnet. Salient permanent-magnet poles on the driving member induce like magnetic poles within the member being driven. These induced poles, once established, resist displacement and tend to maintain alignment with the driving poles. Thus the clutch drives in full couple without heating until the load exceeds the torque rating, whereupon the clutch slips, although maintaining a constant output torque and generating heat. The units are characterized by a high heat dissipation capacity. Eddy currents are generated, too, when the clutch is in slip and these increase in force 3 to 10 per cent for each 1000 rpm increase in slip.

Rotational speeds up to 10,000 rpm are permissible on some types provided the duty cycle does not result in an excessive temperature rise. These devices are usually limited to ratings of 1 hp or less because the unit tends to get bulky in large sizes and its amplification ratio is relatively low—in the order of 15 to 1.

Adjustable-speed service is practical with these units when the load has a rising speed-torque relationship; this insures stability. For example, they could be used on centrifugal fans and pumps. Other applications include machine tool drives; thread cutting; drilling and tapping devices; etc.

Magnetic-Particle Clutches

Another answer to adjustable speed is the magnetic particle or powder clutch. Design details of two types of these units are shown in *Figs.* 4 and 12. Typical applications are shown in *Figs.* 3 and 13. The basic operating parts of this clutch consist of two surfaces with a gap between containing fine ferromagnetic particles or powder. When current flows through the excitation coil, the magnetic particles form chains between the surfaces to hold them together. The shear resistance of the magnetic powder connection made between driving and driven shaft is approximately proportional to the current. The degree of connection provided by the clutch can be controlled from a nonslipping or locked-in connection to complete disconnection. The amount of torque transmitted by the coupling is a function of the magnetic flux generated by the excitation coil regardless of whether the two coupled parts are stationary or rotating.

Application Considerations: The fact that standstill and slipping torques are the same in these units eliminates chatter and also allows torques to be set at standstill. In applying this clutch the maximum amount of torque it will be expected to carry should be carefully evaluated.

Power to energize the excitation coil is quite low —usually ½ to 1/10 per cent of the power handling capabilities. In general, torque is independent of speed and approximately linear in relation to coil current up to saturation of the magnetic circuit parts.

The clutch is not a torque converter and has exactly the same torque on both output and input shafts. Power, a product of torque and speed, is therefore proportional to shaft speeds. If the speeds differ by 2 to 1, the power in and the power out will also be in the ratio of 2 to 1 and the difference will appear as heat in the gap due to slipping.

The clutches will handle large amounts of power for on-off service and are used for slip service where speed or torque control is essential and losses are of secondary consideration. By using proper regulators, the clutches may be employed to control either speed or torque from any signal which can finally be translated into coil current. Response time of magnetic particle units is fast—usually in the order of milliseconds. Magnetic particle clutches are designed with either rotating fields or stationary fields. There appear to be no inherent design limitations in regard to size, and clutches have been developed with capacities up to several hundred horsepower.

Torque: The amount of torque transmitted by the coupling is controlled by the amount of magnetic flux generated by the excitation coil regardless of whether the two coupled parts are stationary or are rotating. Since slip will immediately result if the torque capacity of the clutch is exceeded, it is important to carefully consider any overload that may be expected in any given application. For example, electric motors will carry more than double rated load for a short period of time. If an electric motor is driving a load through a magnetic particle clutch, the clutch may be required to carry any torque the motor develops—as high as 2½ times rated full-load torque.

Speed: Magnetic-particle clutches can provide a constant torque output independently of speed. Because of this ability, these units are very adaptable to controlling speed. There may be clutch designs in which the magnetic-powder particles will align themselves more advantageously in the gap at higher speeds so that torque will increase slightly as speed increases. With magnetic-par-

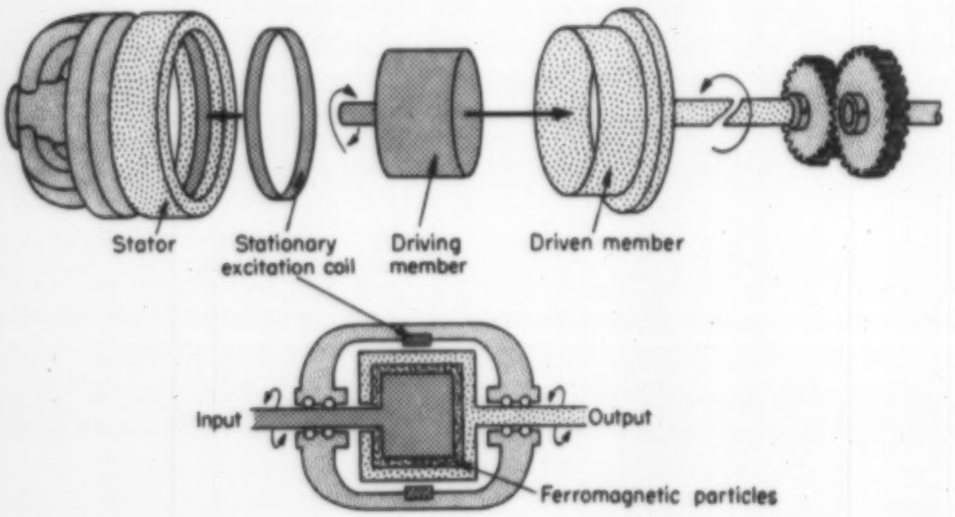


Fig. 12—Components of a typical stationary-coil, magnetic-particle clutch

ticle clutches a simple rheostat can control load speed in the case of a load which has a sharply rising torque-speed characteristic as with centrifugal pumps and fans. In other type loads, a monitoring system may be necessary. A speed-sensitive detector can be used to effect a controlled slip in the clutch in such a way as to hold an output speed constant by continuously adjusting slip speed, *Fig.* 13.

For speed control applications involving highly variable control torques, some form of feedback control system is required. Circuits using tachometers, vibration pickups, or frequency-sensing elements will provide speed control within close tolerances.

Slip Losses: Anytime the speeds at each end of the unit are different, the clutch is slipping and creating heat. In all cases, where magnetic-particle clutches are used for speed control, the selection of a properly designed unit is necessary to be certain that the clutch can withstand the amount of heat generated during slip conditions. Heat dissipation can be aided considerably by proper magnetic-particle clutch design to permit rapid cooling by means of external cooling fins (*Fig.* 13), water cooling, etc. A 400-hp water-cooled clutch which will dissipate over 70 kilowatts has been developed. Although air-cooled units can successfully dissipate large quantities of heat, water cooling is more effective.

In adjustable-speed service, torque may be constant or it may vary with speed. The manner in which torque varies determines the amount of slip loss and the speed at which the maximum loss occurs.

Magnetic-Fluid Clutches

A coupling medium consisting of iron particles suspended in a lubricant is employed in magnetic-fluid clutches. As with the magnetic-particle or powder clutch, transmitted torque is not affected by a change in the slip speed. The performance of the unit is characterized by ease of control, fast and smooth action, high power gain and little or no de-energized torque. These features make the clutch advantageous in applications such as servo drives, and tension and speed control.

Operating Characteristics: Two magnetic-fluid clutches, disk and cup types, are shown in *Fig.* 14.

Fig. 13—Five kw, 400-cycle power supply. Generator is powered by an ac motor through a magnetic-amplifier controlled magnetic-particle clutch. Continual automatic adjustment of clutch slip speed provides constant input speed to generator

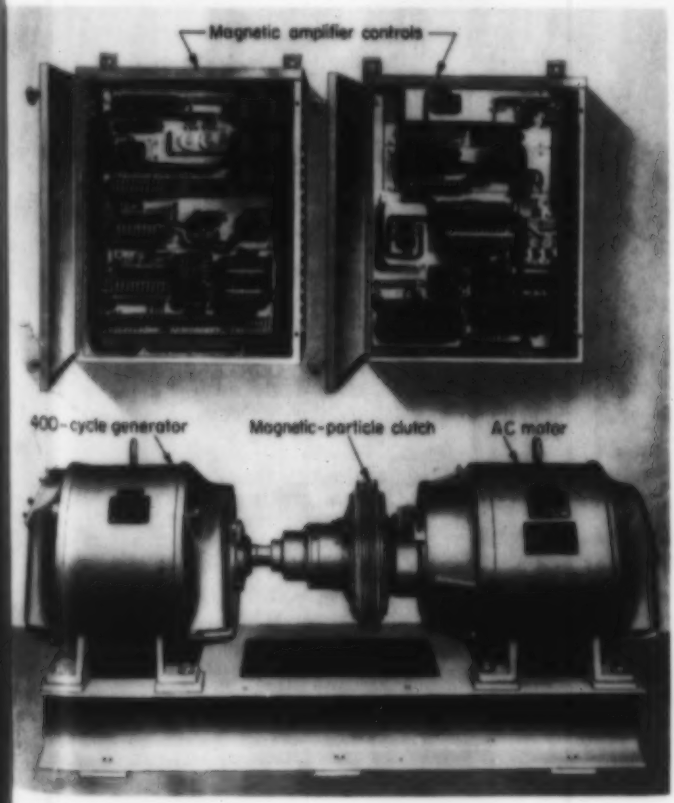
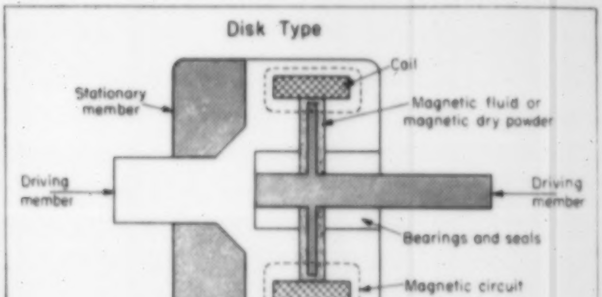

Magnetic amplifier controls
400-cycle generator
Magnetic-particle clutch
AC motor

Fig. 14 — Cross-sections of two typical designs of magnetic-fluid clutches


Disk Type
Coil
Stationary member
Magnetic fluid or magnetic dry powder
Driving member
Driving member
Bearings and seals
Magnetic circuit
Cup Type
Coil
Stationary member
Magnetic fluid
Driving member
Driving member
Bearings
Magnetic circuit

Both designs deliver essentially the same type of operation. The disk type which uses either the dry or fluid medium has a slight minimum drag or de-energized torque caused by the seals and the viscous friction due to the magnetic fluid or the magnetic dry powder. The cup design in *Fig.* 14 employs only magnetic fluid. It does not have any minimum drag due to a "channeling" effect which is possible with this design because of the consistency of the lubricant used to suspend the iron particles. The choice between the use of the magnetic fluid and the magnetic dry powder depends on the application and the performance desired. The fluid medium has a quality of smoothness and the ability to channel in the de-energized state. The magnetic dry powder is smooth but produces a slight de-energized drag.

In recent years there have been great gains made in the performance of the magnetic-fluid clutch. Several years ago the magnetic-fluid life, under an accelerated test, was of the order of 8 hours. Presently the same accelerated test produced a life of approximately 2000 hours. Although the magnetic fluid has a rather definite life, recharging is usually easy. Fluid life depends upon the amount of work performed and this will vary over wide ranges from one application to another.

Application Factors: As with all clutches used for adjustable-speed service the major factors to be considered are slip speed, torque levels, duty cycle and the size of the clutch.

The response time of any magnetic-particle or fluid clutch is dependent on the magnetic circuitry employed in clutch construction. However, a response time of approximately 20 to 40 milliseconds is not uncommon in these units when operated in conjunction with a low-impedance power source such as a battery or simple dry-rectifier circuit. The response can be greatly increased by connecting the clutch coil in series with a high-impedance power source such as a triode or pentode vacuum tube.

Operating speeds of magnetic-fluid clutches are usually in the 0 to 1800-rpm range, and most models are employed only in low-power transmission applications up to $1\frac{1}{2}$ hp.

The selection of a particular clutch for an application depends on (1) torque, (2) operating speed, (3) duty cycle including percentage of slip. Torque and operating speed are known values and are easy to determine. The duty cycle is the percentage of time during one cycle of operation that the clutch will have to dissipate the developed mechanical heat energy through the slip speed. This duty cycle may be difficult to calculate when there could be many variables in one particular application. The amount of heat energy or heat dissipation a clutch will have to handle is

$$W = 0.0119\ TSX$$

where W = heat energy, watts; T = torque, pound-inches; S = slip speed, rpm; and X = fraction of time during a complete cycle of operation that the clutch will have to slip or dissipate mechanical heat energy, per cent. A slip speed versus torque chart such as shown in *Fig.* 15 simplifies heat dissipation calculations.

Fig. 15—Chart for quickly determining heat energy developed for given slip speeds and torques

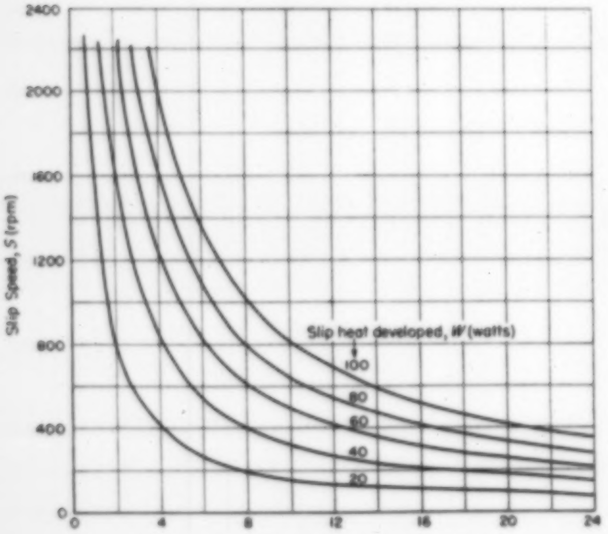
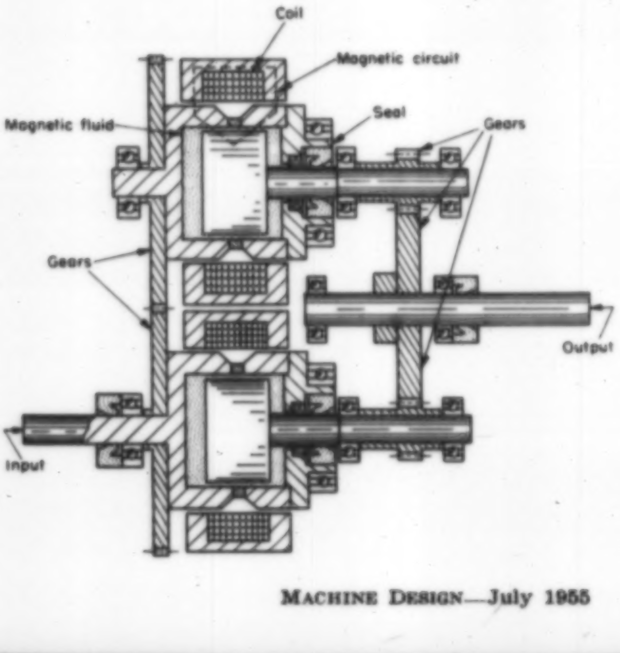


Fig. 16—Reversing transmission with two magnetic-fluid clutches having drum rotor design. Torque and speed are adjustable in either direction



There are many drive applications where the magnetic-fluid clutch has been successfully applied, ranging from simple coupling devices to complex speed controls. Most of these drives can be classified as either "on-off" or "drag" devices. The majority of the magnetic-fluid clutches have been used for reversing transmissions, *Fig*. 16. These transmissions have been designed to incorporate two magnetic-clutch elements and associated gearing into a light, compact unit with some designs provided with an oil bath for lubrication and cooling. The clutch elements and gearing produce an adjustable torque that is controllable in either direction of rotation with a single directional prime mover. The oil bath provides additional cooling for the clutch element to facilitate greater work loads. Such transmissions have been successfully applied in air-borne radar antenna scanning drives and for primary controls of flight simulators.

Magnetic-fluid clutches have been used as dual-speed drives for various coil and foil winding applications. Magnetic-fluid clutches may be geared up or down to provide suitable torque ranges within which tensions can be delicately controlled by the current through the coil as a compensation for the change in diameter of a coil or spool with a change of speed and torque so that fine delicate material can be processed very effectively.

ACKNOWLEDGMENT

MACHINE DESIGN acknowledges with appreciation the co-operation of these companies in the preparation of this article:

Louis Allis Co. (*Fig*. 1)	Milwaukee, Wis.
Dynamatic Div., Eaton Mfg. Co. (*Figs*. 2, 5, 6, 7, 8 and 9)	Kenosha, Wis.
Electric Machinery Mfg. Co. (*Figs*. 10 and 11)	Minneapolis, Minn.
General Riveters Inc.	Buffalo, N. Y.
Lear Inc. (*Fig*. 4)	Grand Rapids, Mich.
Raymond Engineering Laboratory Inc. (*Figs*. 14, 15 and 16)	Middletown, Conn.
Vickers Electric Div., Vickers Inc (*Figs*. 3, 12 and 13)	St. Louis, Mo.

Electrical Insulating Seal For High Pressure Applications

MEASUREMENT and control of high pressures often require electrical connections to the interior of a pressure vessel without leakage. In certain industrial operations, pressures as high as 100,000 psi are encountered. An insulating seal made of commercially available and relatively inexpensive parts, yet combining mechanical strength with good electrical insulating properties, has been designed by the National Bureau of Standards. The seal has successfully withstood pressure to 170,000 psi.

Made to accommodate four wires, the NBS seal utilizes a sapphire insulating bushing to provide the physical characteristics required. Quartz may also be used as an insulator. Other parts of the seal include a soft steel electrode, a rubber O-ring, and a soft steel pad.

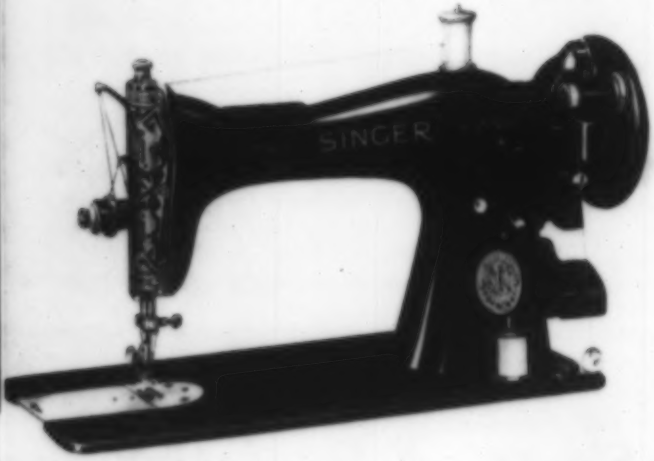
The soft steel pad fits directly into the closure plug cavity and supports the insulating bushing. A hole in the bushing accommodates the tapered soft steel electrode to which the electrical connection is soldered. As a result of the taper, only the outer rim of the tapered surface makes contact with the bushing, unless very high pressure is applied. The rubber O-ring separates the larger-diameter part of the electrode from the wall of cavity in the closure plug.

In operation the seal acts in two stages. The O-ring provides the initial low-pressure seal through its compression contact with the electrode and the interior wall of the cavity in which the assembly is installed. This seal probably lasts up to about 30,000 psi. Then, at about the pressure that the O-ring becomes ineffective, the tapered section of the electrode is deformed against the bushing, thereby sealing off the leakage path between the bushing and the electrode. Simultaneously, or shortly thereafter, the soft steel pad is deformed by pressure, sealing off the leakage path between the bushing and the wall of the plug cavity.

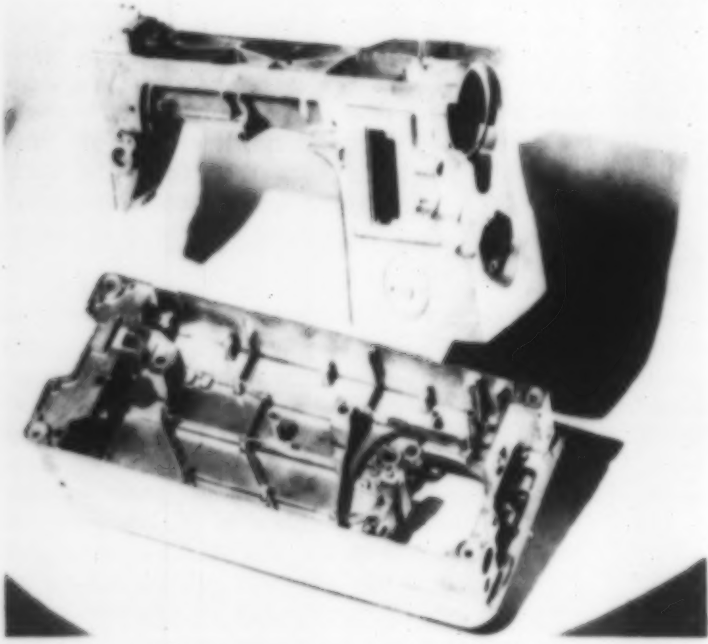
The high-pressure seal can be simplified considerably by choosing softer bushings that do not require the soft steel pad. With this type of seal, bushings of lithographic limestone have been used successfully. However, great care must be given to the selection of the limestone since this stone has flaws which may cause the bushings to crumble under load. Once a flawless piece has been selected, it is easily turned on the lathe using sharp tools, preferably carbide, and taking small cuts.

"The comprehensive designer should, first of all, be motivated by very broad concepts of human thought and behavior. Broad because a viewpoint should be worldwide rather than national or local. Second, he must be thoroughly familiar with the organism for which he is designing and the total environment in which his product must operate. Third, he must be articulate in all types and all levels of communication. Fourth, he must be able to maintain a delicate balance between his ability to analyze, to synthesize, and to evaluate. And last, he must have complete understanding of and mastery in the use of the creative process."—JOHN E. ARNOLD, *associate professor of Mechanical Engineering, Massachusetts Institute of Technology.*

Redesigned Sewing Machine Uses Aluminum Die Castings



AN intricate, thin-walled base and an even more complex upper frame form the basic sewing head of the newly designed Singer model 301 sewing machine. Both of these pieces are large aluminum die castings. Die-cast end cover, top cover, bed extension plate and lamp shade complete the housing. Weight reduction resulting from the use of aluminum die castings permits the sewing head to be used in both portable and cabinet machines. Actual weight of the machine is less than half that of earlier models.



PREVIOUSLY extensive machining and surface finishing were required. Die castings eliminate the necessity of surface finishing and many previously required machining operations because of the close tolerances maintained in the casting process. The motor housing seat is cast-in and provides precise locating for the motor.

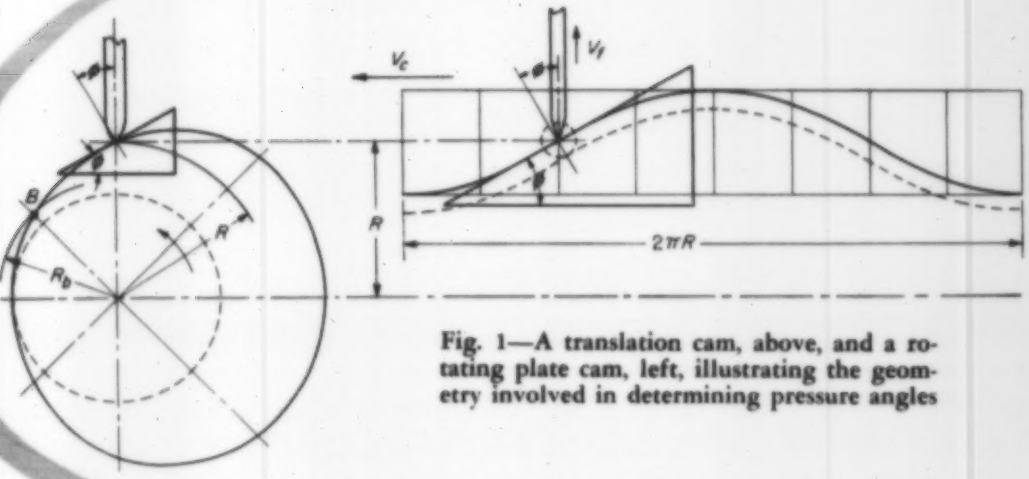


Fig. 1—A translation cam, above, and a rotating plate cam, left, illustrating the geometry involved in determining pressure angles

A rapid and accurate method for checking

Cam Pressure Angles

By R. T. Hinkle
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LARGE pressure angles for cam and follower systems can cause rough operation, excessive wear and even binding or jamming. Pressure angles can always be kept small if large cams are used. This approach is more expensive and frequently space requirements are such that a compromise must be used. Often the maximum follower load does not coincide with the position of maximum pressure angle. In such cases it is often desirable to check the pressure angles at the maximum load positions. The method described here can be used to determine accurately and rapidly the pressure angle for any point or, for an assumed pressure angle, to determine the required radius of the pitch contour at that point.

A relatively inaccurate method for determining pressure angles is to lay out the cam profile and measure the angles formed by radial lines and common normals. Special equations have been developed for more accurately determining pressure angles for certain types of motion.

A simple expression that can be used to determine the pressure angle, ϕ, for any radial follower motion for any position is

$$\phi = \tan^{-1} \frac{V_f}{V_c} \qquad (1)$$

where V_f is velocity of follower, and V_c is velocity of point of contact on pitch curve in inches per second. This can be most easily seen from a translation cam with knife edge follower, *Fig.* 1. A tangent triangle is drawn at the point of contact. The pressure angle is the angle whose tangent is the ratio of the two legs of the triangle. The horizontal and vertical legs represent the cam velocity and follower velocity, respectively. These legs can also be thought of as virtual displacements drawn to a large scale.

A roller follower and corresponding cam outline are shown with dotted lines in *Fig.* 1. Since the center of the roller follows the path of the knife edge the pressure angles for corresponding positions will be the same for both. Hence the development here can be confined to the knife edge follower.

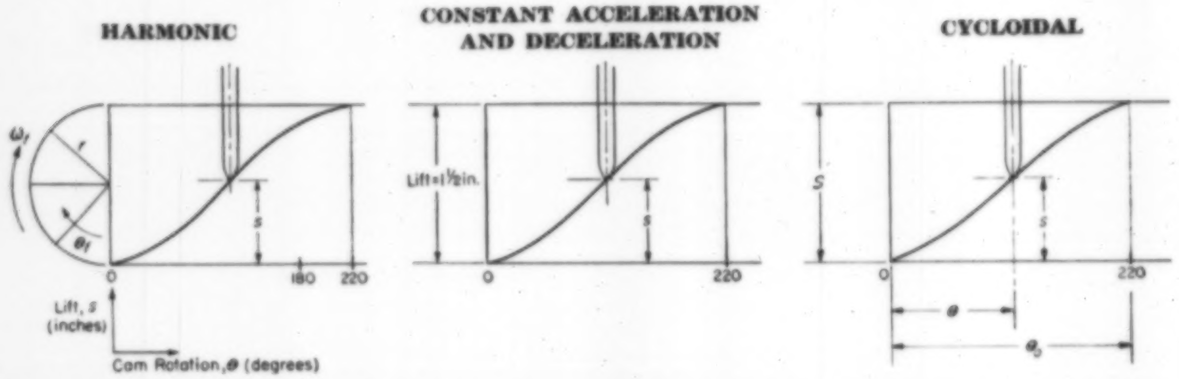
The translation cam can also represent the profile of the plate cam, *Fig.* 1, rectified about the radius *R*. If the pressure angle is to be measured graphically it will be correct only for points that correspond to radius *R*. If the pressure angle at *B* is to be measured graphically by this method, the displacement curve must be rectified for R_b; that is, the length of the base is $2\pi R_b$.

When Equation 1 is used there is no need for graphical work. The tangent triangle can be thought of as existing at each point on the cam pitch curve as shown in *Fig.* 1.

Three examples are shown in *Fig.* 2. In these examples the minimum pitch radius is 3 inches and the lift is 1½ inches corresponding to 220 degrees of cam rotation.

The radius can be determined for a chosen pres-

For all examples: base radius of cam = 3 inches; angular velocity of cam, $\omega_c = 1$ radian per second = $360/2\pi$ degrees per second; maximum pressure angle, ϕ_{max} occurs at $s = \frac{3}{4}$ inch, $\theta = 110$ degrees; V_c = velocity of point of contact on pitch curve; V_f = velocity of follower in inches per second; and t = time in seconds.



$$s = r - r\cos\theta_f = r - r\cos\omega_f t$$

$$V_f = r\omega_f \sin\theta_f = r\omega_f \sin\omega_f t$$

$$\omega f = \omega_c \frac{180}{220} = 0.816 \text{ rad per sec}$$

$$V_f = r\omega_f \sin\theta_f = \frac{3}{4}(0.816)(1)$$
$$= 0.613 \text{ in. per sec}$$

$$V_c = R\omega_c = 3.75\ (1)$$
$$= 3.75 \text{ in. per sec}$$

$$\phi = \tan^{-1}\frac{V_f}{V_c} = \tan^{-1}\frac{0.613}{3.75}$$
$$= 9^\circ\ 16'$$

$$s = \frac{1}{2}at^2 = \frac{1}{2}vt$$

$$V_f = \frac{2s}{t}$$

Time for 1 revolution of cam = 2π sec
For 110 degrees of cam rotation:

$$t = 2\pi\frac{110}{360} = 1.92 \text{ sec}$$

$$V_f = \frac{2s}{t} = \frac{2(0.75)}{1.92}$$
$$= 0.78 \text{ in. per sec}$$

$$V_c = 3.75 \text{ in. per sec}$$

$$\phi = \tan^{-1}\frac{0.78}{3.75} = 11^\circ\ 45'$$

$$s = S\left(\frac{\theta}{\theta_o}\right) - \frac{S}{2\pi}\sin\frac{2\pi\theta}{\theta_o}$$

$$V_f = \frac{S\omega_c}{\theta_o} - \frac{S\omega_c}{\theta_o}\cos\frac{2\pi\theta}{\theta_o}$$

$$V_f = \frac{1.5\ (1)}{\frac{220}{360}(2\pi)} \times \left[1 - \cos\frac{2\pi\ (110)(57.3)}{220}\right]$$
$$= 0.78 \text{ in. per sec}$$

$$V_c = 3.75 \text{ in. per sec}$$

$$\theta = \tan^{-1}\frac{0.78}{3.75} = 11^\circ\ 45'$$

Fig. 2—Examples of pressure angle calculations for three types of cam profiles

sure angle if Equation 1 is written in the form

$$R = \frac{V_f}{\omega_c \tan\phi} \quad\text{(2)}$$

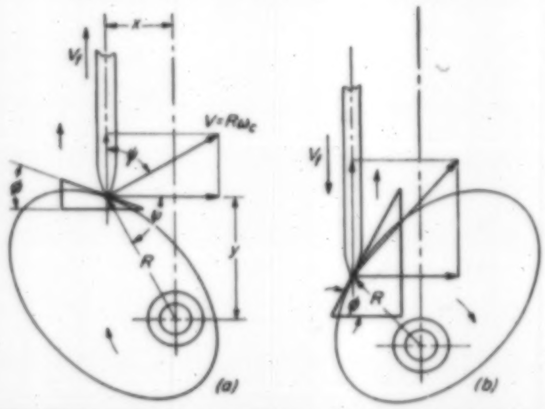
where R = radius of cam at point of contact, inches; and ω_c = angular velocity of cam, radians per second.

Offset Followers: The same method can be used to determine pressure angles for offset followers, *Fig. 3a*. Here again the tangent triangle moves in the direction of $V = R_\omega$, but this vector is not horizontal. It is convenient to work with the vertical and horizontal components of this velocity. The vertical component is

$$V_{fv} = R\omega_c \cos\psi$$

where V_{fv} = vertical velocity component of follower, inches per second; and ψ = angle between

Fig. 3—Geometry for deriving pressure angles with a plate cam and offset follower. For clockwise cam rotation and follower offset to the left, illustrations are for upward motion, *a*, and return motion, *b*



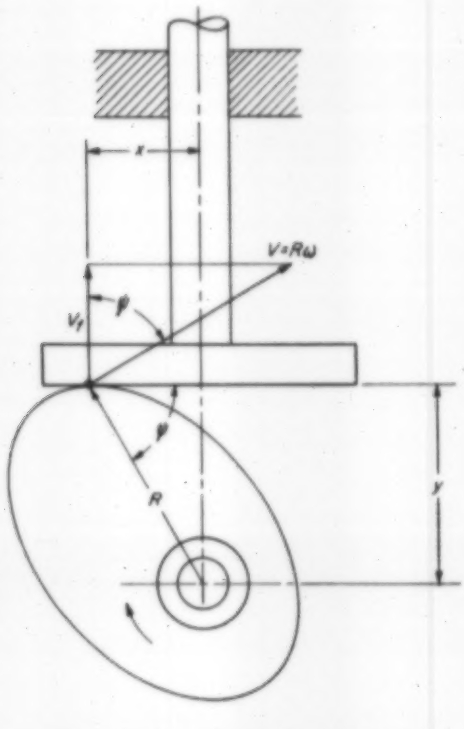


Fig. 4—Geometry involved in determining location of the point of contact between a plate cam and a flat-face follower

the vertical and the velocity of the point of contact on the cam. The component of follower velocity, V_{fh}, due to horizontal motion of the wedge is

$$V_{fh} = R\omega_c \sin\psi \tan\phi$$

But

$$\cos\psi = \frac{x}{R} \text{ and } \sin\psi = \frac{y}{R}$$

where x = offset, inches; and y = vertical distance between center of rotation of cam and point of contact, inches. Then

$$V_f = V_{fv} + V_{fh} = x\omega_c + y\omega_c \tan\phi$$

or

$$\phi = \tan^{-1}\frac{V_f - x\omega_c}{y\omega_c} \quad \text{(3)}$$

The condition for return motion is shown in *Fig. 3b*. Since the vertical component is always upward for a cam rotating clockwise with follower offset to the left, the pressure angle must be large if the resultant V_f is to be downward. Following the foregoing derivation, with proper signs, yields

$$\phi = \tan^{-1}\frac{V_f + x\omega_c}{y\omega_c} \quad \text{(4)}$$

The maximum pressure angle can be determined by plotting a curve for a series of values.

The same theory can be used to determine the location of the point of contact between a plate cam and a flat-face reciprocating follower. From *Fig.* 4, the following relationship can be developed:

$$x = \frac{V_f}{\omega_c} \quad \text{(5)}$$

From Equation 5 it can be seen that x is a maximum when V_f is a maximum. Also, for a given motion x is independent of the cam size.

Plastic Machine Slides

Plastic laminate strips as bearing surfaces can reduce friction between sliding machine parts. In one application, plastic slides on a Morrison cloth-stretching machine have increased operating speed and reduced power consumption.

In service, the plastic strips wear along one edge. When worn, the strips may be removed and turned to an unworn edge. In this way they may be used several times before being discarded.

Phenolite, an asbestos-base laminate made by National Vulcanized Fibre Co., was used to form the strips used on the Morrison machine. These strips are made from ⅜-inch stock, 2¾ inches wide and cut into 5-foot lengths. They are fastened to the machine by ½-inch cap screws. To allow for expansion in the heated chamber, a gap is left between the strips at each rail joint, and mounting holes are drilled 1/32-inch oversize.

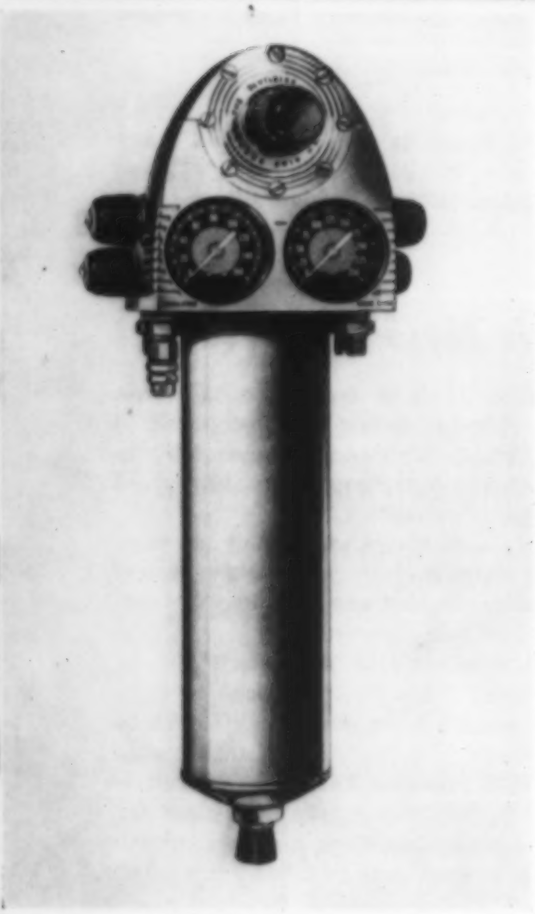
Should lubrication be neglected, the plastic bearing strips wear but will not damage the metal sliding surfaces. The plastic strips can be replaced easily if damaged.

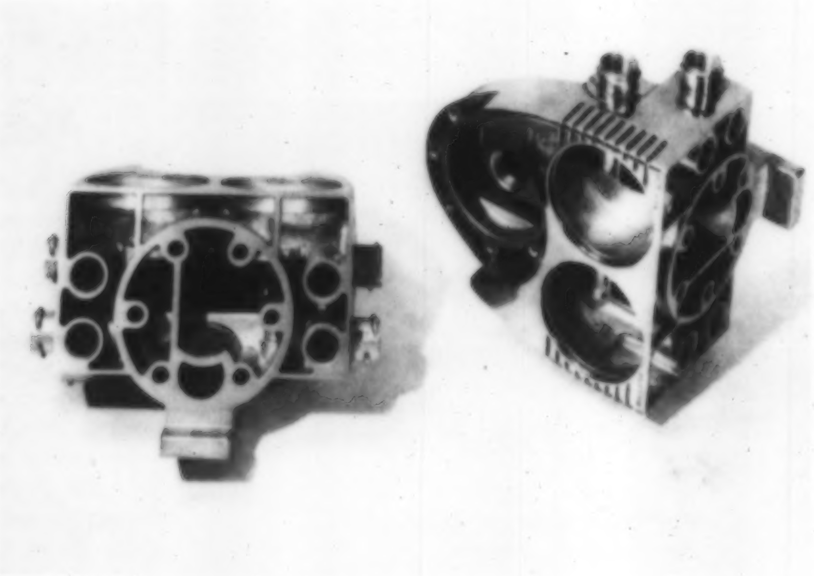
They Say . . .

"The engineer's principles of logical analysis can be most helpful where applied to social and political problems, not forgetting that they should be accompanied with sympathy when concerned with problems of human beings."—HON. THOMAS C. DESMOND, *member, New York State legislature.*

"Engineers have been described as those who direct the natural forces of nature to the uses and benefits of mankind. This has been the profession's historic role. But, to fulfill this function today, we, as engineers, must be far better equipped than we were a generation ago. For, just as our technology has grown more complex, so have the social and political forces which exert pressure on our environment—forces exerted by labor, by government, or even by the courts. If engineers are to contribute their best, they must understand these forces just as well as they do the stresses and strains of physical phenomena."—HENRY B. DU PONT, *vice president, E. I. du Pont de Nemours & Co.*

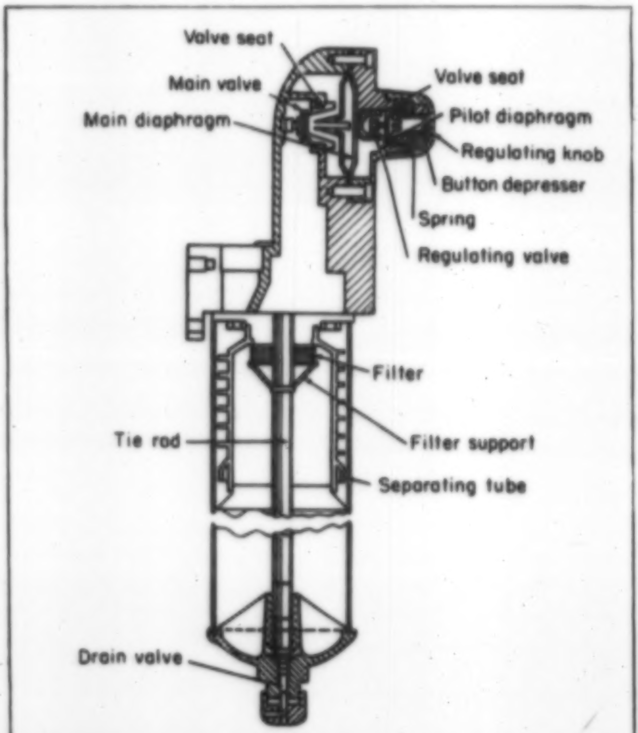
Air Transformer Uses Intricate Die Casting





A N INTRICATE zinc die casting forms the head of a combination air filter and pressure regulating valve, labelled an air transformer by its manufacturers, the De Vilbiss Co. The die casting, made by New Products Corp., is said to cut costs by eliminating machining and finishing operations, and provide a sound pressure-tight structure with the necessary strength and dimensional stability for operation at pressures of 250 psi. Gages showing both inlet and regulated outlet air pressures mount directly in the head. Four outlets for regulated air are provided.

After passing through the centrifugal moisture separator and disk type dirt filter attached to the bottom of the transformer head, air is admitted to the outlet passage of the head and passes through the main valve to the outlet passage. A regulating knob as well as inlet air pressure control the degree of flex of the pilot diaphragm which in turn controls the position of the regulating valve. As pressure at the regulating valve increases or decreases, the main daiphragm is acted upon by the regulating valve to either increase or decrease the amount of flex of the main diaphragm. Pressure exerted by the main diaphragm on the main valve varies the outlet pressure. This arrangement produces regulation of 20 to 1; main line pressure must vary by 20 pounds to produce a change of 1 pound in outlet pressure. Maximum regulated pressure is 135 psi for input pressure of 250 psi. Maximum capacity is 100 cfm.


Valve seat
Main valve
Main diaphragm
Valve seat
Pilot diaphragm
Regulating knob
Button depresser
Spring
Regulating valve
Filter
Tie rod
Filter support
Separating tube
Drain valve

Tables and Charts for Calculating

Thermal Expansion of Metals

By Donald Marshall
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In calculating the linear expansion or contraction of metals and alloys used in design, considerable time may be consumed in locating in the literature coefficients of linear expansion values. Commonly accepted thermal expansion coefficients for several commercially pure metals are listed in *Table* 1 while *Table* 2 covers 13 alloys. Both tables have listings at five temperatures over a −100 to 800 F temperature range. If coefficient values at temperatures other than those given are needed, it may be desirable to make a plot of points on a coefficient-of-linear-expansion versus temperature chart. Construction of a smooth curve through the plot of points, as done for 13 alloys in *Fig*. 1, permits the determination of approximate values for any intermediate temperature. It is usually desirable for the sake of accuracy to use the coefficient of linear expansion at the mean temperature between the temperature extremes a machine or any particular part of that machine is expected to encounter.

Table 1—Thermal Expansions of Commercially Pure Metals

Metal	Coefficient of Linear Expansion (0.000001-in. per in. per deg F) At −100 F	At 68 F	At 300 F	At 450 F	At 800 F
Aluminum (Al) ...	10.1	12.44	14.4	—	16.05
Cadmium (Cd)	—	16.2	20.1	—	—
Chromium (Cr) ...	4.0	3.78	5.0	—	—
Copper (Cu)	7.2	9.0	9.28	—	11.1
Gold (Au)	7.7	7.88	8.35	—	8.96
Iron (Fe)	6.25	6.55	7.23	—	10.8
Lead (Pb)	14.5	16.3	17.5	18.35	—
Magnesium (Mg) ..	13.0	14.44	15.85	16.45	—
Manganese (Mn) ..	12.85	12.94	13.0	—	—
Molybdenum (Mo)..	2.83	2.94	3.01	—	3.2
Nickel (Ni)	6.44	7.0	8.17	—	11.65
Platinum (Pt)	4.27	4.96	5.2	—	5.55
Silver (Ag)	9.1	10.25	10.9	—	11.4
Tin (Sn)	10.1	14.96	15.15	—	—
Titanium (Ti)	12.8	14.6	—	16.8	—
Tungsten (W)	2.2	2.30	—	—	3.17*
Zinc (Zn)	16.4	17.0	19.68	—	—

*Coefficient of linear expansion at 1440 F.

Chart Solution: Length increase or decrease in a piece of metal caused by a temperature change alone can be calculated by the expression

$$(\triangle L) = (\triangle T)\,KL$$

where $(\triangle L)$ = linear dimension change, inches; $(\triangle T)$ = temperature change, degrees F; K = coefficient of linear expansion, inches per inch per degree F; and L = length of piece, inches. The alignment chart in *Fig*. 2 is based on this formula and provides a quick and easy method of solving thermal expansion and contraction problems.

To find the length change in a piece of metal using with the nomograph in *Fig*. 2, first draw a straight line from the temperature differential value, $(\triangle T)$, to coefficient of linear expansion, K, taken at the mean temperature between the expected temperature extremes. From the point on the turning axis where this first construction line crosses, draw a straight line to the proper point on the L scale corresponding to the length of the piece. The intersection of this line on the $(\triangle L)$ scale gives the incremental change in piece length. By a similar approach any one of the other factors could be determined if three of the terms are known.

Example 1: If the drawing dimension for a piece of 304 stainless steel is 12.000 inches long at 68 F, find the actual length of this dimension at 268 F.

DATA SHEET

The mean temperature is 168 F. From *Fig.* 1 the coefficient of thermal expansion for 304 stainless steel at 168 F is 9.55×10^{-6}. The temperature change ($\triangle T$) = 268 − 68 = 200 F.

To solve for ($\triangle L$), draw on *Fig.* 2 a line from 200-degree value on the temperature change scale to a reading of 9.55×10^{-6} on the coefficient of linear expansion scale. Then from the intersection of this line with the turning axis, draw a straight line to a reading of 12 on the length of piece scale. Then read 0.023-inch at the intersection of the linear dimension change scale. Therefore, the piece length at 268 F is 12.000 + 0.023 = 12.023 inches.

Example 2: If the same factors are given as in Example 1 except the higher temperature is 1000 F, what would be the actual length of the piece at 1000 F.

The mean temperature is 534 F. From *Fig.* 1, K is 10.55×10^{-6} and ($\triangle T$) is 932 degrees. From the alignment chart, ($\triangle L$) = 0.12-inch. Therefore the length of the piece at 1000 F is 12.12 inches.

Table 2—Thermal Expansions of Several Alloys

Alloy	Coefficient of Linear Expansion (0.000001-in. per in. per deg F) At −100 F	At 68 F	At 300 F	At 500 F	At 800 F
Aluminum					
Wrought—2024	9.6	11.4	13.45	—	15.3
Cast—195	10.2	11.9	12.8	—	15.2
Copper Alloys					
Brass, cold-rolled (Cu-Zn)	9.1	10.2	12.0	—	12.6
Bronze (Cu-Zn-Pb-Sn)	—	10.4	11.1	12.0	—
Manganese bronze (Cu-Mn)	—	7.45	8.23	8.78	9.6
Silicon bronze (95 Cu-3.2 Si)	—	8.26	7.25	—	9.85
Iron, cast	—	6.63	7.72	8.45	9.2
Magnesium, cast	11	13.2	13.4	15.2	16.3
Monel Metal (Ni-Cu-Fe-Mn)	—	7.58	—	8.42	9.45
Steel Alloys					
High carbon—1090	—	5.37	5.77	7.3	7.8
Low carbon—1025	6.0	6.38	7.35	8.1	9.1
Stainless—304	8.3	9.2	9.7	—	11.1
Stainless—440	—	5.6	6.5	—	8.38

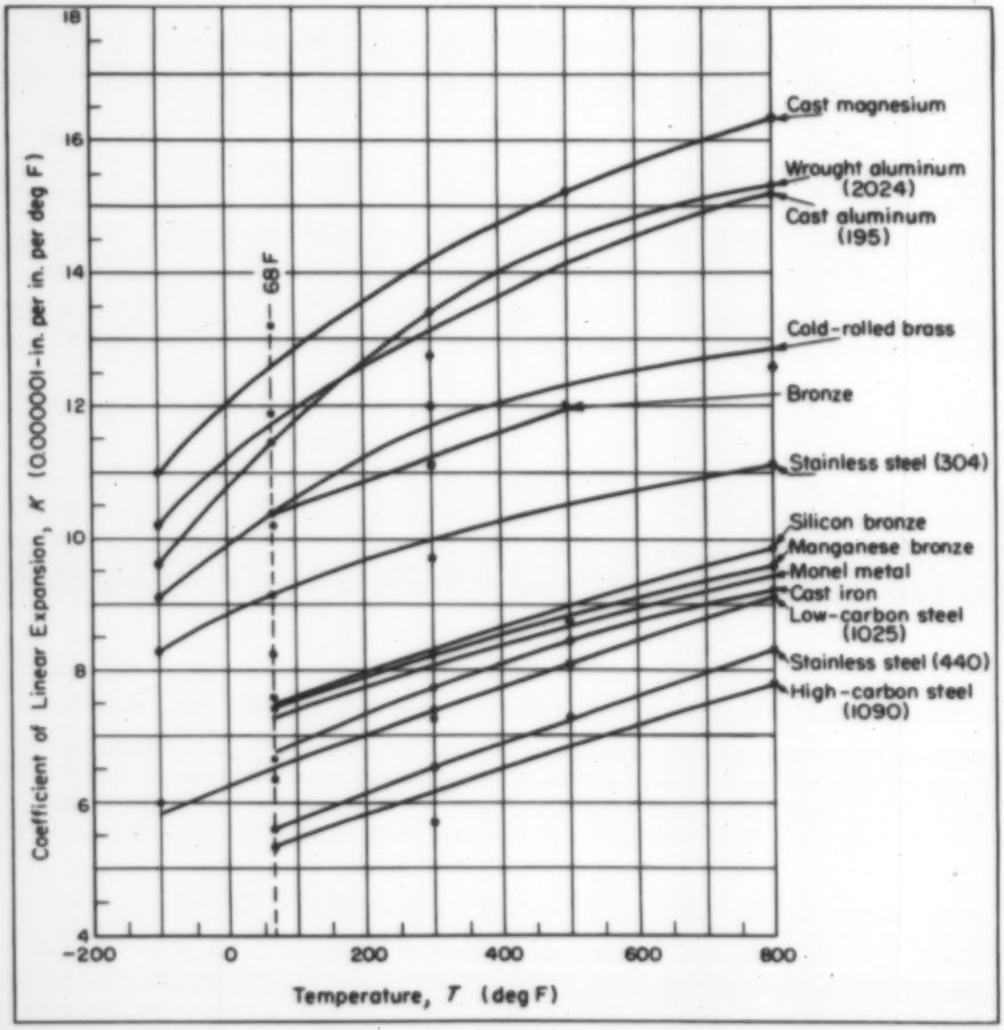
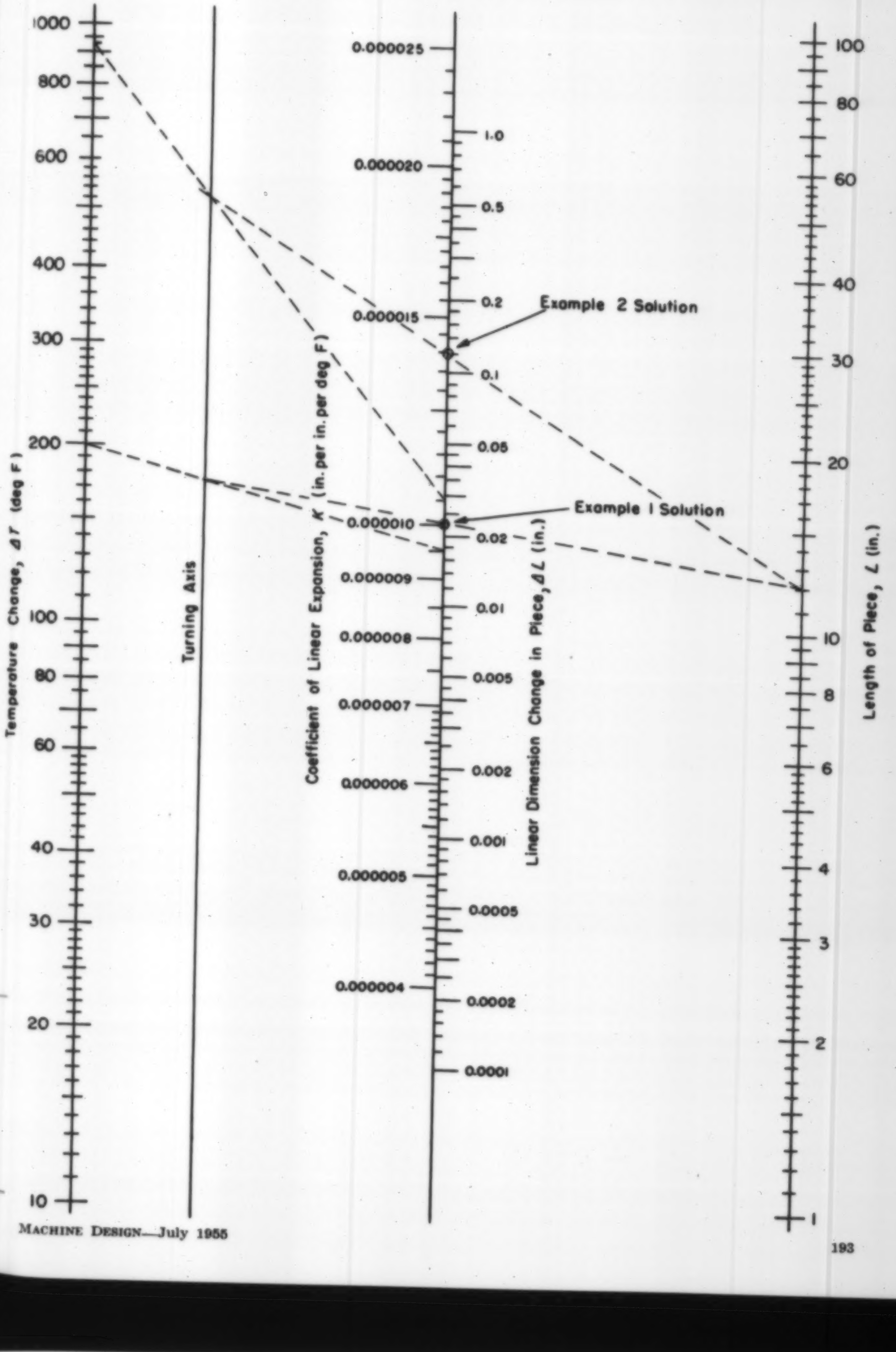


Fig. 1—Curves for determining approximate coefficients of linear expansion of 13 alloys at any temperature between −100 and 800 F. Chart curves were drawn by using data from *Table* 2

Fig. 2 — Nomograph for finding thermal expansion or contraction of a given length of metal resulting from a given temperature change

THERMAL EXPANSION OF METALS



DESIGN ABSTRACTS

Evaluating piston pumps and motors for . . . . .

High-Performance Hydraulic Systems

By R. H. Marvin*
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The Franklin Institute
Philadelphia, Pa.

WITHIN recent years there has been an increased demand for the use of variable-speed hydraulic transmissions in feedback control systems. The demands placed upon hydraulic transmissions to meet the requirements of these servo systems has sometimes increased faster than the industry's cognizance of the important requirements. The pump is no longer just a generator of hydraulic pressure, and the motor no longer a device to convert flow to rotary motion. The combination of pump and motor becomes an integrated part of a complete system.

For purposes of this discussion, a high-performance system is one which is capable of responding to high-frequency input signals, such as shown in *Fig.* 1. Other combinations of variable and fixed displacement units may be used, but this particular one is representative of the type of system that occurs frequently, and its features will be discussed here.

Piston pumps have generally proved to be the most satisfactory for this kind of high-performance system. The transmission is one in which the electrically driven pump has variable displacement, and the load-driving motor has fixed displacement. Stroke or displacement of the variable-displacement machine is controlled by a linear motor and flow-control valve which is actuated by a solenoid, torque motor, or equivalent actuator. The variable-displacement unit is driven by a constant-speed source, and may be equipped with a flywheel.

Output shaft of the fixed-displacement unit is coupled to an inertia load which, for the purpose of this discussion, will be con-

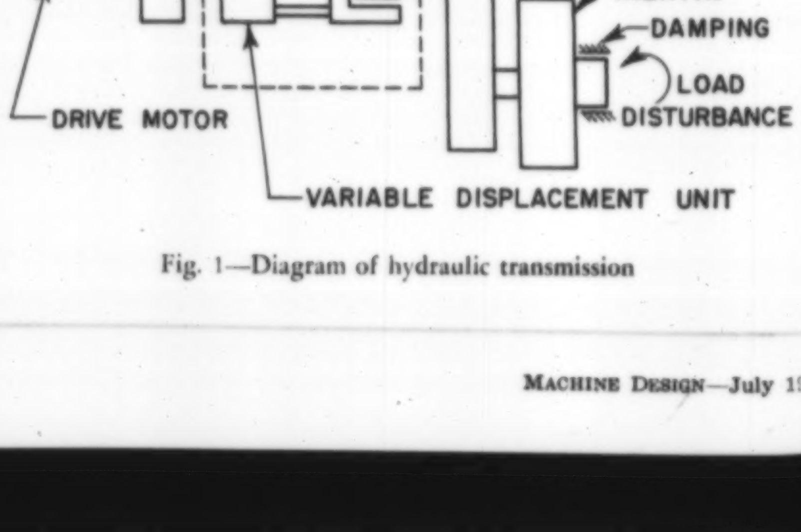

Fig. 1—Diagram of hydraulic transmission

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*Now with New York Air Brake Co., Watertown, N. Y.

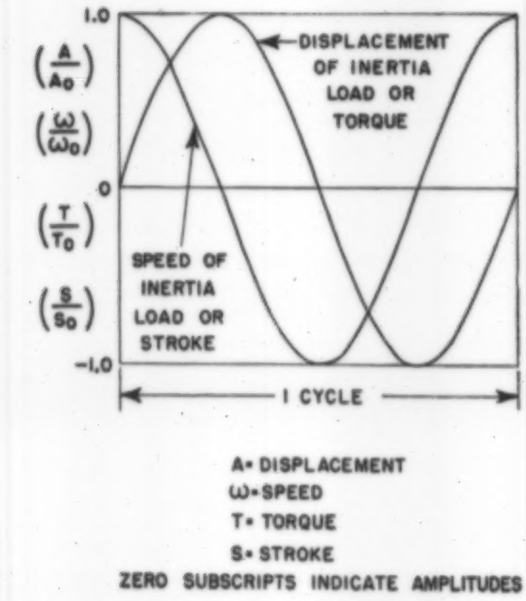

Fig. 2—Typical duty cycle of hydraulic transmission

sidered fairly large with respect to the effective inertia of the fixed-displacement unit. Viscous resistance occurs at the output of the fixed-displacement unit, and there is some external load disturbance. However, inertia of the load constitutes the main load on the system.

This form of transmission is commonly used in systems where the position of the fixed-displacement unit is made to coincide with some input signal. Generally this transmission is employed where peak acceleration of the load is desired at all speeds. Therefore, full torque must be available at all speeds. Such transmissions are built to deliver peaks up to 500 hp. The transmission must be equipped with replenishing check valves and relief valves to make it complete.

Main points that should be considered in the selection of hydraulic machines for systems where good dynamic performance is required are:

1. Peak power and reliability
2. Dynamic considerations
    a. Appropriate parameters for fixed-displacement units
    b. Volume of fluid in the active system
3. Stroke characteristics
    a. Stroke forces
        (1) Centrifugal
        (2) Hydraulic
    b. Inertia
    c. Friction
4. Efficiencies
    a. Volumetric
    b. Mechanical
    c. No-load or standby losses

These factors are listed purely on the basis of how they affect performance, and no mention has been given to economic considerations. Initial cost of equipment and maintenance costs are certainly items which must ultimately be considered.

Peak Power and Reliability: Quite naturally, the primary requirements governing the selection of any set of fixed and variable-displacement units for the transmission in question, are that it have adequate power capacity and the ability to withstand sufficient hours of the duty cycle of operation.

Dynamic Considerations: For the transmission in question there is no requirement, with the possible exception of weight and space, that the rotating inertia of the variable-displacement unit be low. In fact, in many hydraulic systems of this type, a flywheel is coupled to the variable-displacement unit to serve as a stabilizing influence in maintaining constant speed, in preventing large fluctuations in the current to the electric drive motor, and in maintaining uniform displacement of the variable-displacement unit at a particular stroke setting.

For efficient storage of energy, the flywheel would normally be run at the higher drive-motor speed. In systems where the duty cycle is similar to that of *Fig.* 2, the flywheel at the drive motor supplies some of the energy so that the power of the electric drive motor need not be as great as the peak power delivered by the variable-displacement unit. This is particularly true where the load on the output is essentially an inertia load and the energy is merely transferred between the load and drive flywheel, the electric power motor only making up the mechanical losses in the system. In general, the inertia of the variable-displacement unit is not critical.

Inertia of the fixed-displacement element of the transmission is a different matter. This inertia is coupled to the load through gearing or some equivalent and may, in some cases, operate at many times the load speed. Its inertia must be increased by a factor equal to the square of the gear reduction between output shaft and load when referred to the load speed. With reduction of the order of 200 or 300 to 1, inertia of the motor may be of the same order of magnitude as the load inertia, and therefore plays an important part in the power capacity of the transmission. In electric drives of this sort the reflected inertia of the variable-speed electric motor may approach the inertia of the load. Thus, there should be some criteria for the selection of the fixed-displacement elements, and some parameters which will give an indication of which element will be most advantageous from the standpoint of power capacity of the unit involved.

Time and Power Constants: There are two parameters which have significance, and the proper use of them will lead to minimizing the amount of power absorbed within the fixed-displacement unit as the load is accelerated to its maximum velocity. These are the "time constant" of the fixed-displacement unit and the "time-rate-of-power constant."

"Time constant" is the time required to bring the fixed-displacement rotor up to peak operating speed with no external load. It is directly proportional to maximum speed and inertia of rotating parts and inversely proportional to maximum torque.

"Time-rate-of-power constant" is the peak horsepower delivered by the fixed-displacement unit divided by the time constant.

For hydraulic equipment in general it is not necessary to evaluate fixed-displacement units in terms of load characteristics, but use of the time-rate-of-power parameter is sufficient in itself. Actually, in terms of the physical characteristics of the fixed-displacement unit, the time-rate-of-power-constant is proportional to the torque squared divided by inertia. It is emphasized that in comparing this parameter for a specific application, the comparison is only valid as long as the maximum horsepower output of both units is identical. In other words, it is not correct to evaluate or distinguish between the time-rate-of-power constant of hydraulic machines which differ in peak horsepower rating. Listed in *Table* 1 are some typical values of these parameters, showing how inertia, reflected at load speed, is affected.

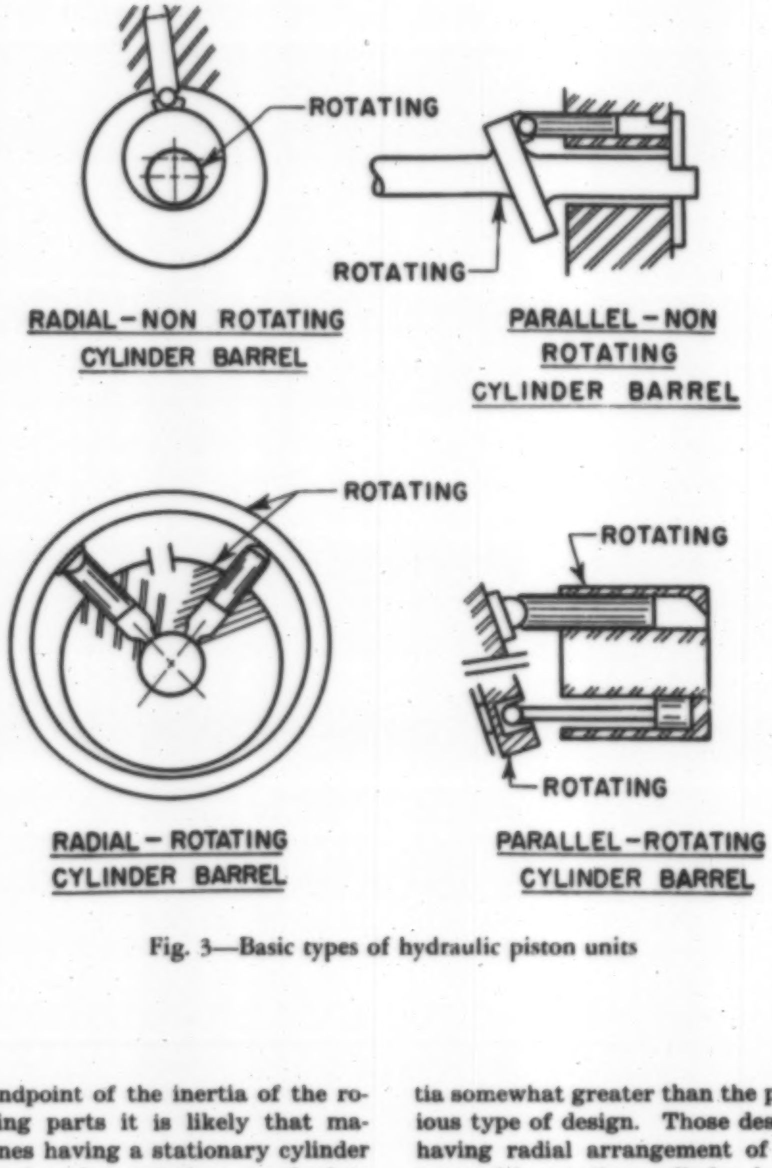
ROTATING
ROTATING
RADIAL-NON ROTATING CYLINDER BARREL
PARALLEL-NON ROTATING CYLINDER BARREL
ROTATING
ROTATING
ROTATING
RADIAL-ROTATING CYLINDER BARREL
PARALLEL-ROTATING CYLINDER BARREL

Fig. 3—Basic types of hydraulic piston units

Inertia Considerations: Inertia of fixed-displacement units is a function of the method by which reciprocating motion of the pistons is achieved. Several basic designs of a fixed-displacement piston unit are shown in *Fig.* 3. From the standpoint of the inertia of the rotating parts it is likely that machines having a stationary cylinder barrel and a rotating swash-plate or eccentric will have the smallest inertia. However, the type of valves in such machines may make a significant contribution. The design which has a rotating cylinder barrel with pistons arranged parallel to its axis would have an inertia somewhat greater than the previous type of design. Those designs having radial arrangement of pistons with rotating cylinder barrel possess the highest inertia of the three classifications.

In radial machines in which the reacting member rotates, a large mass is concentrated at the major diameter of the rotating parts, and consequently its inertia adds ap-

Table 1—Operating Characteristics of Fixed-Displacement Hydraulic Units

Unit	Maximum Torque (lb-in.)	Inertia (lb-in.-sec^2)	Peak Intermittent Speed (rad/sec)	Peak Power (hp)	Time Constant (sec)	Rate-of-Power Constant (hp/sec)	Gear Ratio*	Reflected Inertia (lb-in.-sec^2)
A	3543	0.360	160	86	0.01625	6,150	640	382
B	4540	0.310	125	86	0.00855	10,050	500	200
C	4170	0.246	136	86	0.00801	10,720	544	188

*Based on maximum-load speed of ¼-radian per second.

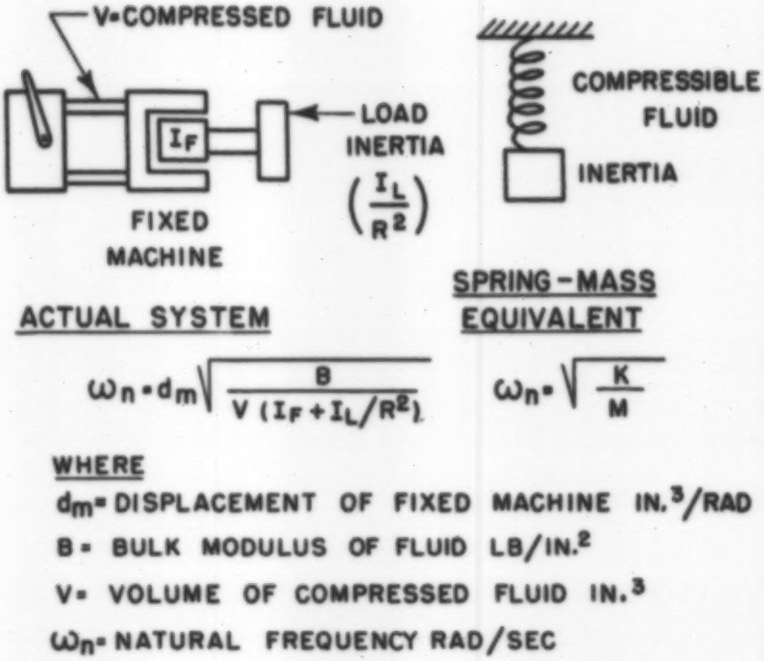
V=COMPRESSED FLUID
I_F
LOAD INERTIA
$\left(\frac{I_L}{R^2}\right)$
FIXED MACHINE
ACTUAL SYSTEM
COMPRESSIBLE FLUID
INERTIA
SPRING-MASS EQUIVALENT
$\omega_n = d_m\sqrt{\frac{B}{V(I_F+I_L/R^2)}}$
$\omega_n = \sqrt{\frac{K}{M}}$
WHERE
d_m = DISPLACEMENT OF FIXED MACHINE IN.^{3}/RAD
B = BULK MODULUS OF FLUID LB/IN.^{2}
V = VOLUME OF COMPRESSED FLUID IN.^{3}
ω_n = NATURAL FREQUENCY RAD/SEC

Fig. 4—Natural frequency of transmission and load

preciably. For high accelerations, the reacting member of such radial machines may skid relative to the piston contact points or piston shoes, as the case may be. However, frictional resistance between the shoes or pistons and the reacting member is probably sufficient to prevent this slippage, and therefore the reacting member must be included in the inertia. Although inertia alone is not the criterion for best dynamic characteristics of the fixed-displacement unit, it does have a very strong influence on determining the magnitude of the time-rate-of-power parameter.

Fluid Compressibility: In systems which have large inertia coupled to the output of the fixed-displacement unit, compressibility of the fluid within the active hydraulic system may be of real significance. The fluid which is subject to elastic deformation is partially contained within the variable and fixed-displacement units and partially contained within the piping or manifolds between the two units.

As indicated in *Fig.* 4, the natural frequency of the system composed of the transmission and the effective inertia at the output of the fixed-displacement unit is approximated by the expression shown. For a unit of given displacement, the smaller the volume of fluid contained in the high-pressure side of the hydraulic coupling, the higher will be the natural frequency of this system. Where the load is required to respond to high frequency input signals, the natural frequency of the transmission and load must be comparable with the frequency of the signals which are to be imposed. In these systems, therefore, the volume of compressible fluid must be small.

Some variable-displacement machines and some fixed-displacement machines, because of their construction, do not permit the intimate arrangement that is desired. The natural frequency might vary for four different transmissions as shown in *Fig.* 5. Each transmission has sufficient output power to meet the power requirements of the load. The essential difference lies in the amount of fluid that is contained within the system when the variable and fixed-displacement units are placed as close together as is feasible. This is represented by the zero line in *Fig.* 5.

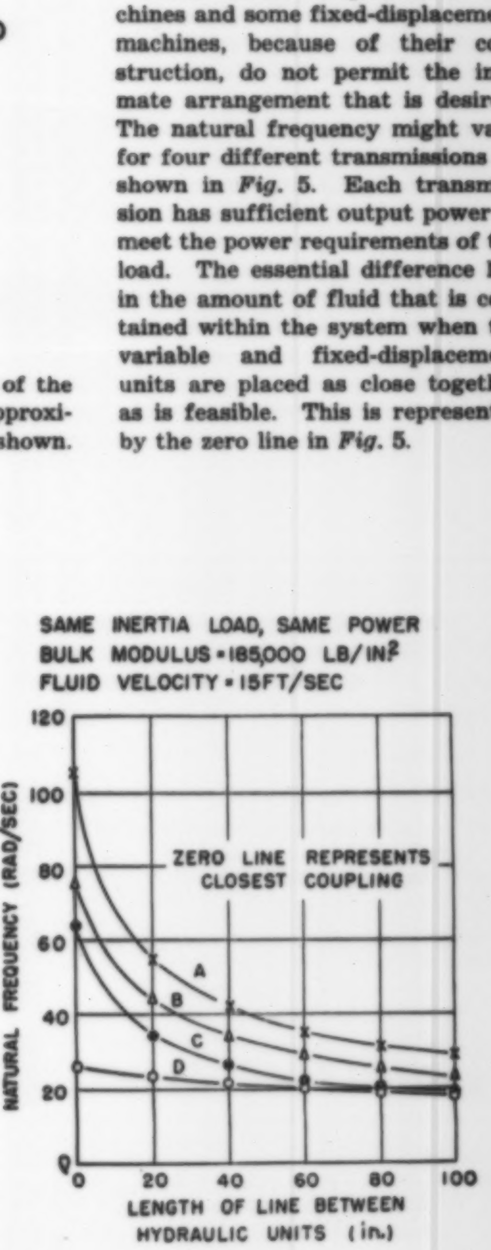

Fig. 5 — Natural frequency as a function of length of connecting line for four different transmissions

Transmission *A* is one in which the valve plate for the two units is common. Relief and check valves are mounted in the common valve plate. This represents one of the best configurations for minimum oil under compression. At the other extreme, transmission *D* is one which because of porting arrangement inherently contains a large volume of oil under compression.

Referring to *Fig.* 5 again, if now the two units must be separated, and because of the length of lines more fluid is contained within the active system, the natural frequency will consequently be reduced. Transmission *A* is more suited for applications where the variable and fixed displacement units must be separated. The reason for this is the small volume of fluid contained within the inlet and outlet connections of the variable and fixed-displacement machines.

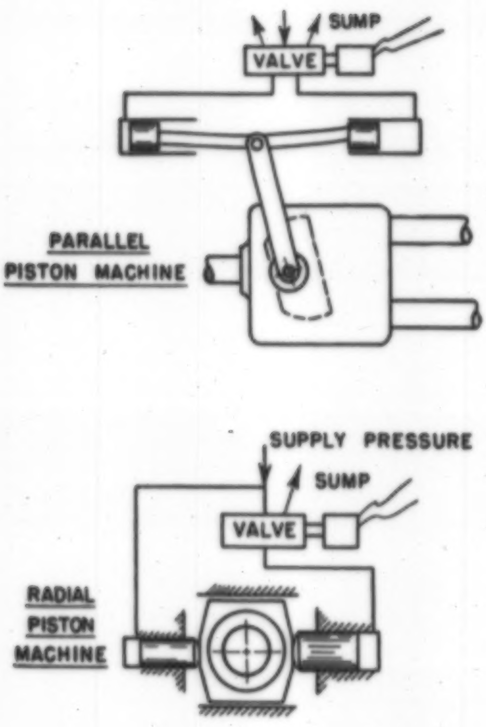

Fig. 6 — Two valve-controlled stroking systems

Stroke Characteristics: Generally a valve-controlled system will be employed to move the stroked elements to the desired position. Two schemes that might be employed for this purpose are indicated in *Fig.* 6.

If the stroke servo is slow and unstable, the movable elements will not adjust to their proper position quickly and without oscillation. Inertia of the stroking parts is one of the factors of prime importance. Should this inertia be excessively large, natural frequency of this stroke servo will be low. This is not desirable if the stroke parts are to be positioned with desired speed of response.

The other important factor inherent in the variable-displacement machine is the forces which are exerted on the stroked parts by the variable unit. These forces are attributed, in general, to three different phenomena: (1) centrifugal effects which come about due to the dynamic action of pistons and other rotating parts within the unit, (2) forces of hydraulic origin which are proportional to the pressure in the active system at the time, (3) frictional resistance to the moving stroke parts.

In radial machines, for example, which rely upon guide rails to support the load of the reaction members, friction may be developed between the rails and the stroked parts. This can have the serious effect of producing discontinuities in stroke position, which in turn will be reflected in the output of the transmission.

The forces required to change the stroke of the variable-displacement machine must be continuous and as small as practicable. In some applications there should be a tendency for the stroked parts to return to their neutral position if pressure to the stroke actuator is lost. In summary, it is desirable to be able to hold stroke position under all conditions of operation with a minimum of error.

Mechanical and Volumetric Efficiencies: These efficiences of the combination of variable and fixed-displacement units have a very definite effect upon the overall system. Leakage produces damping and, as such, plays an important part in the dynamic performance of the system. In order that the damping be sufficient for some applications, leakage might advantageously be increased to improve performance.

High leakage has a tendency to produce a dead zone around zero stroke when there is appreciable friction in the mechanical parts driven by the fixed-displacement unit. For the kind of loads which have been specified here, this dead zone would be negligible. In some power drives, however, there will be friction. The dead zone resulting from this friction requires that the stroke parts move through a finite distance in an extremely short period of time if the output of the transmission is to be continuous through zero stroke.

High leakage can pose a serious heat problem in this kind of transmission. This is particularly true in drives that must deliver several hundred horsepower at the peak. Even though the peak power requirement may be of short duration, the leakage from the high-pressure side to the case or low-pressure side represents a large amount of energy. Since this energy appears as heat it tends to raise the temperature of the entire hydraulic system. In many installations, there is a real gain if one does not rely upon heat exchangers to maintain a safe working temperature. High leakage might mean the difference between requiring a heat exchanger or getting by with natural heat dissipation by convection and radiation. Extreme leakage can also cause local hot spots which may accelerate breakdown of the hydraulic fluid.

There are limitations on the minimum allowable leakage. Leakage past pistons and valve faces, etc., must be sufficient to insure proper lubrication and proper cooling of points that may be critical in these respects. However, should the leakage be less than adequate to give sufficient damping to the complete system, a suitable velocity feedback from the output of the fixed-displacement unit can be employed to give the desired damping. Use of such a feedback loop may be more advantageous than the dissipation of large quantities of heat.

No-Load or Standby Losses: One of the consequences of poor mechanical efficiency may be large no-load or standby loss. By this is meant the power required to turn the variable-displacement unit at zero stroke. In transmissions such as these, the duty cycle is often such that the peak power demands on the system are only made for short durations of time. For a large percentage of operating time the unit may be operating around zero stroke with small power output. As stated before, much of the input power requirements can come from a flywheel. In the interest of keeping weight and size down, a small electric drive motor can be used. Following periods when the peak power has been demanded, and the flywheel has dropped its speed and also given up some of its energy, the drive motor must bring the flywheel back to its synchronous speed in order to be ready for the next demand. If the no-load losses are excessive, the electric drive motor must be sufficiently large to overcome these losses and also be able to bring the flywheel back to speed. Further, if the no-load losses are high and the energy dissipated maintains a high temperature level at all times, there is little reserve heat capacity for absorbing dissipated energy when the load is high. One of the main causes of high no-load loss, which is particularly serious at high speed, is the resistance offered to the cylinder barrel or rotating parts by the fluid in the case or housing. For the same speed, the drag on radial machines is more pronounced than it is on parallel-piston type machines since their rotating elements are usually of larger diameter.

Other Design Factors: All the factors discussed here regarding fixed and variable-displacement piston machines pertain to the relationship of these components to the performance of a complete hydraulic transmission. Admittedly there are many other important factors which must be considered in the selection of components, for example, the shape of the transmission and the ease with which it and its accessories fit into the allowable space. Weight of equipment may be extremely important.

Some applications require that noise be minimized. This can be important where the equipment must operate near personnel who would be adversely affected by noise. Noise being generally tied in with the time rate of change of pressure, components which operate at high speed will be most objectionable. For the hydraulic transmission described here, the fixed displacement machine must operate both over a range of speeds and a range of pressures. This latitude in operating conditions makes noise reduction a compromise at best.

From a paper of the same title presented at the ***10th*** *annual National Conference on Industrial Hydraulics sponsored by Illinois Institute of Technology in Chicago, Ill., October,* **1954.**

Developing Reliable Electronic Controls

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INDUSTRIAL electronic motor controls have demonstrated a spectacular ability to control large amounts of power precisely in response to low-level signal voltages. However, the electronic control has been slow to gain complete acceptance because generally it has not met industry reliability standards for motor-control equipment.

Specific complaints directed at electronic devices are observable by direct comparison with typical magnetic control devices rated for industrial service. Features proved by experience and long usage to promote reliability in industrial control devices, but usually lacking in electronic equipment, are:

1. Sufficient spacing between terminals of opposite polarity and to ground to maintain safe electrical creepages, thereby reducing arc-overs and low leakage resistances.
2. Insulation capable of withstanding adverse atmospheric conditions.
3. Screw terminals to provide positive electrical connections which are easily removed for servicing.
4. Mechanically rugged assemblies.
5. Easy maintenance and service.

To this list must also be added the requirement for more reliable and rugged electron tubes.

Packaged Unit: Using conventional components, an idea has been developed that supplies industrial features to electronic components. This idea has been identified as a Reliance product by the title "Sealpak."

The Sealpak is a miniature packaged unit containing a single standardized functional circuit. It is mechanically protected and sealed in a high-dielectric plastic material; has replaceable high-reliability miniature tubes, all screw terminals with 600 volt NEMA standard creepages, and can be serviced by a simple function test. A screwdriver is the only tool needed to make replacements.

This unit contains only integral circuits with easily identified standard functions. To increase life and reduce unpredictable failure, High Reliability tubes are used.

The High Reliability tube is a development sponsored by Aeronautical Radio Inc. This group, in cooperation with private industry, has set up rigorous manufacturing standards aimed at producing a restricted line of tubes of superior reliability for use in airline communications and navigation applications. The main effort was aimed at reducing the unpredictable type of failure which eludes most maintenance procedures and results in unreliable equipment performance. High Reliability tubes show a great reduction in this type of failure.

Finally, the manufacturing cost of a complete Sealpak had to be low enough that in the interest of simplified, rapid service, the replacing of complete functional circuits rather than individual components would be accepted.

Basic electronic motor control was examined and found to fall into roughly the following functional types.

1. Power supplies.
2. Phase-shift circuits.
3. Dc amplifiers.
4. Signal limit circuits.
5. Linear time-voltage circuits.
6. Thyratron rectifiers.

Designs of each type were studied and one of each developed with the flexibility required for use in the majority of controls.

Models of each circuit were built, and to obtain maximum utilization of space, all positioning and mounting hardware was eliminated. Parts were taped into a compact bundle and wired together. By careful design and arrangement of parts, the hazard of accidental electrical contact between parts was reduced to a minimum. The resulting optimum package size for the Sealpak unit determined from the models was found to be 3¼ by 4⅝ by 3¾ inches.

A metal case fitted with a sixteen-terminal barrier terminal strip was designed to these dimensions. With the circuits wired to the terminal board and enclosed in this case, the requirement for screw terminals had been fulfilled. However, there was still the problem of electrical creepages between components in the bundle, and protection against adverse atmospheric conditions, to say nothing of the heat insulating properties of dead air, and the tendency the circuit bundle would have to ground out against the sides of the container. The answer, of course, was to embed the entire assembly in an insulating material. Chosen for this was a thermosetting plastic compound that is fluid in its normal state, and that solidifies permanently when treated with a catalyst.

A line diagram of the power supply, consisting of an anode transformer, four selenium rectifiers,

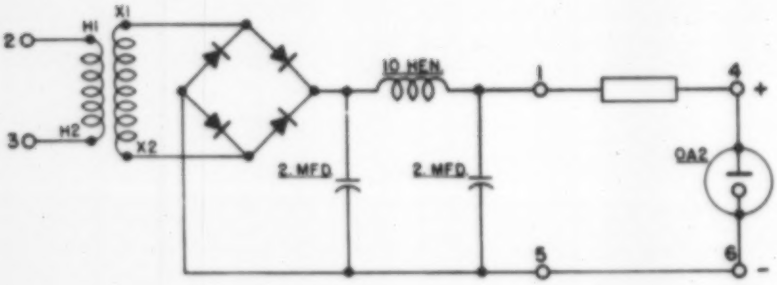


Fig. 1—Power supply consisting of an anode transformer, four selenium rectifiers, two filler capacitors and a choke. It is rated at 150 volts, 0.050-amp

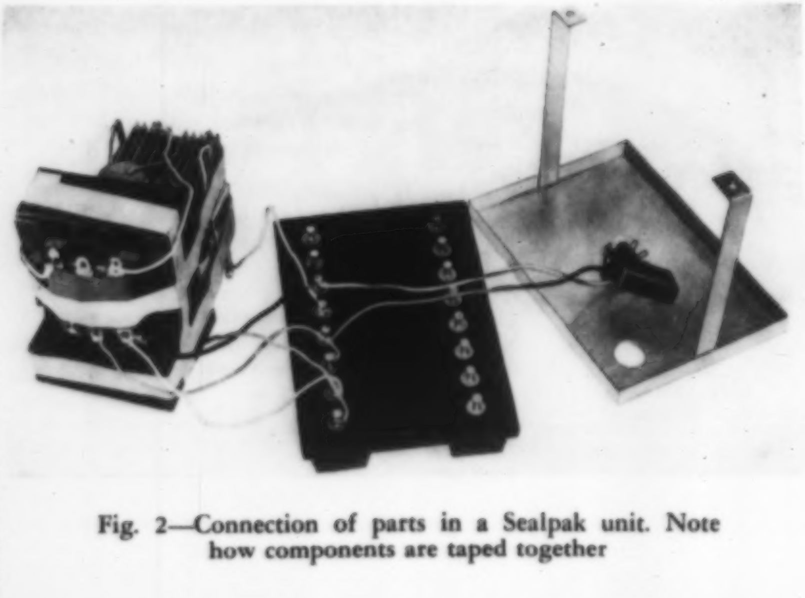
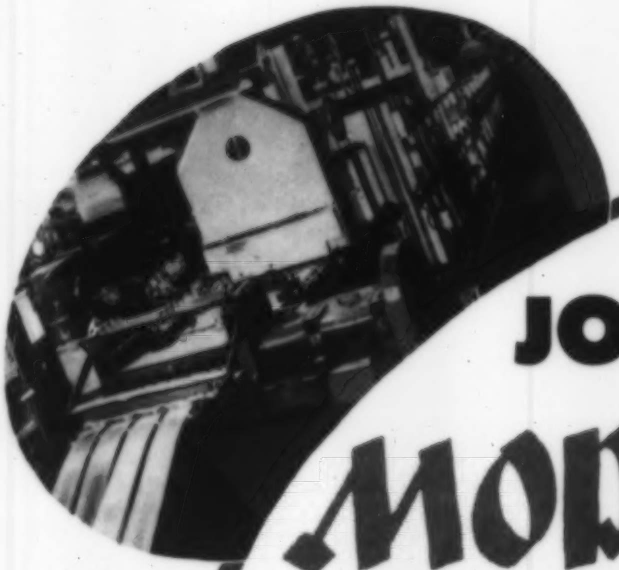


Fig. 2—Connection of parts in a Sealpak unit. Note how components are taped together



JOHNSON MODERNIZED SLEEVE BEARINGS

SOLVE MANY SPECIFIC PROBLEMS

The sleeve bearing is basic in principle . . . for most applications man's genius has never invented any device to replace it. For instance, every internal combustion engine is dependent on it, and the majority of industrial equipment is, too. But modern requirements, high speeds, higher loads, and changing designs have called for new sleeve bearings. Johnson Bronze, alert to the demands of new engineering trends, is producing Johnson Modernized Sleeve Bearings, capable of giving the utmost service under these modern conditions. Aluminum bonded to steel is one of them. Copper-lead bronze-on-steel is another. New materials, new combinations of materials and new designs are meeting many new requirements. If you have a specific sleeve bearing problem, perhaps a Johnson engineer can help you. Write for an appointment.

JOHNSON BRONZE COMPANY
525 South Mill Street, New Castle, Pa.

JOHNSON JB BEARINGS
Sleeve-Type

JOHNSON BRONZE PRODUCES ALL TYPES OF SLEEVE BEARINGS: ALUMINUM-ON-STEEL • CAST ALUMINUM ALLOY • BRONZE-ON-STEEL, copper lead • STEEL BACK, babbitt lined • BRONZE BACK, babbitt lined • CAST BRONZE, plain or graphited • SHEET BRONZE, plain or graphited • LEDALOYL powder metallurgy two filler capacitors and a choke, is illustrated in *Fig.* 1.

The physical assembly of the parts is shown in *Fig.* 2. Note how the individual components are taped together. There is little chance of accidental contact here prior to the embedding operation, and, once embedded, each mil of plastic thickness is capable of withstanding 320 volts.

The completed unit in its metal case ready for use is shown in *Fig.* 3.

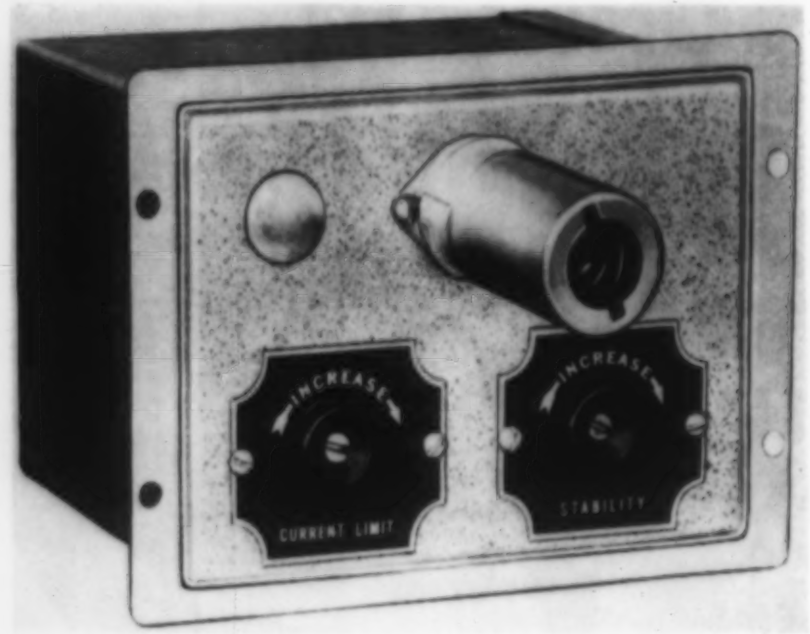


Fig. 3—Completed Sealpak unit in its metal case

Application: Typical application of Sealpak units is illustrated by their use in the regulator control in *Fig.* 4. The clean, simple layout of this relatively complicated electronic control is apparent.

Six Sealpak units are used in this control: two 150-volt power supplies, a dc amplifier, a phase-shift bridge, a limit control and a thyratron rectifier. All of the units are in the metal case described previously, except the thyratron unit, which is better adapted to the conventional chassis-type container shown.

The problem of locating a defective part is reduced to six units instead of numerous resistors, capacitors and miscellaneous small parts.

From a paper entitled "Increasing the Reliability of Industrial Electronic Control with 'Sealpak' Components" presented at the AIEE Special Conference on Machine Tools in Detroit, Mich., October, 1954.

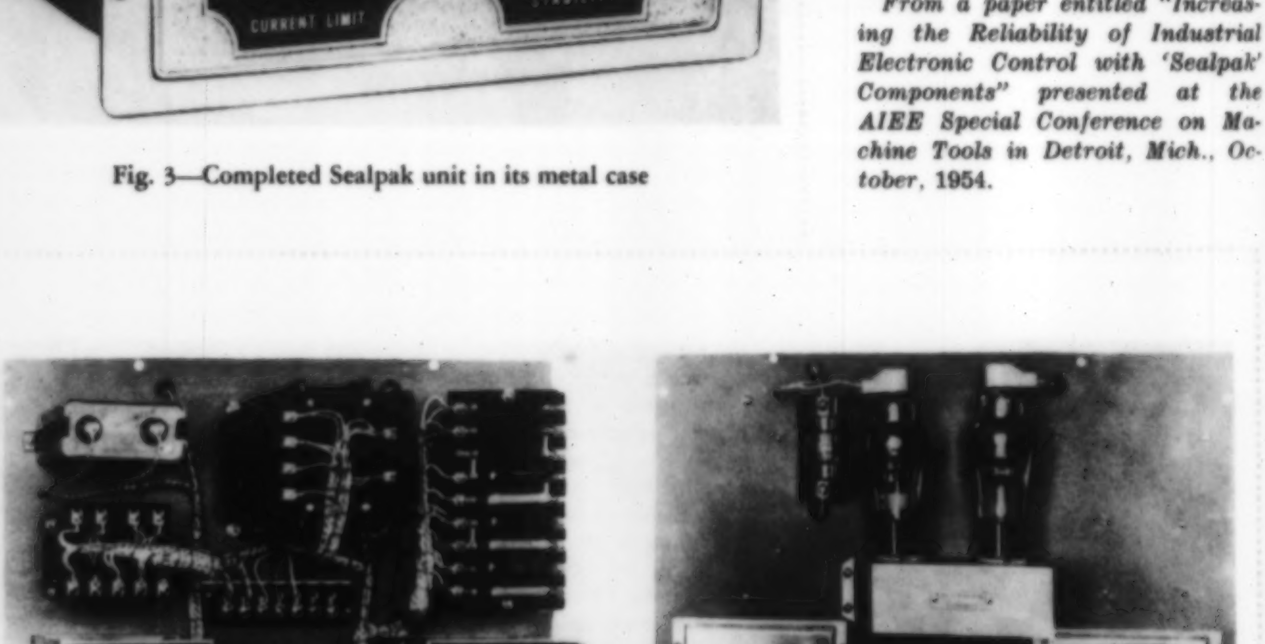


Fig. 4—Regulator control using packaged components

Here's How

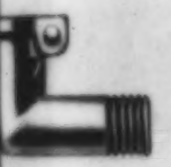
GITS

Helps Give

Built-In Low Cost To YOUR Equipment

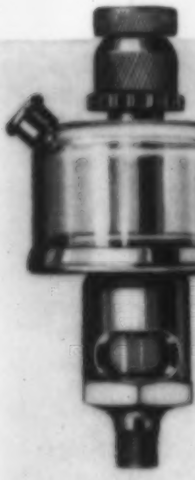
OIL HOLE COVERS

This model is designed to fit into a simple drilled hole. Ideal for use on small motors, generators, starters and light machinery—for dependable oil hole protection at moderate cost. Larger sizes frequently used as filler caps on tanks or reservoirs. Style R—No. 305.



OIL CUPS

curately machined from a
d brass one-piece forging,
oil cup permits safe, de-
dable application of lubri-
t at very low cost. Used
ely on motors and small ma-
ery requiring side oiling.
e L—No. 1202.



SIGHT GRAVITY FEED OILERS

Rate of oil flow regulated by needle valve, directly observed through sight glass in stem. Shut-off knob does not affect needle valve adjustment. Visible oil supply. Non-breakable. Tops in convenience and dependability, at low cost. Style NFU—No. 3602-A.

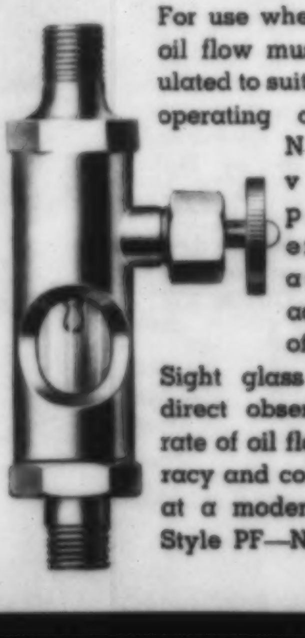
GEAR CASE GAUGES

This oil gauge plug permits instant checking of oil level within a transmission or gear case. For use where construction permits insertion in tapped hole. A valuable addition to any such equipment — at very low cost. Style BW—No. 4042.

SIGHT GRAVITY FEED MULTIPLE OILERS

one unit replaces 3 to 8
ividual oilers. Maximum
cticality in a small central
ication system. Positive cut-
during idle periods. Individ-
vibration-proof needle valve
ustments. With solenoid con-
(Illustrated): Style MDS—
4685-A. Without solenoid:
MD.

SIGHT GAUGES



For use where rate of oil flow must be regulated to suit changing operating conditions. Needle valve permits extremely accurate adjustment of oil feed. Sight glass provides direct observation of rate of oil flow. Accuracy and convenience at a moderate price. Style PF—No. 4290.

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A design appraisal of

Prealloyed Steel Powders

By G. A. Roberts and A. H. Grobe
Vanadium-Alloys Steel Co.
Latrobe, Pa

PREALLOYED steel powders are powder metals with each individual particle having the same composition, microstructure, hardenability, and other characteristics as alloy steels in the massive state.

Two general types of prealloyed steel powders have commercially important applications. One group is composed of the high-strength, low-alloy steel powders where hardenability is an important factor, and the other comprises the stainless-steel powders where corrosion resistance is required. It would be impossible to obtain the properties of these two types of prealloyed steel powders by mixing elemental powders. Diffusion rates of the common alloying elements in steel are so slow that complete alloying is not attained in commercial sintering times. The only useful element that can be alloyed with iron in a short time is carbon, which can be added to iron powder as graphite before pressing by a gas-metal reaction to porous compacts during sintering, or by surface carburizing treatment of dense compacts.

In the low alloys, a steel powder could be readily produced by the addition of carbon to iron, but the finished compact will have low hardenability. If sections over ¼ to ½-inch thick have to be hardened, alloying elements are necessary. These alloying elements have to be uniformly dissolved to be effective, and thus prealloyed high-strength, low-alloy steel powders have gradually and recently proved their value.

It is impossible to get truly stainless materials without prealloyed powder. Stainless-steel compositions must have a uniform distribution of all of the alloying elements to provide the protection from corrosion that is characteristic of each type. Stainless-steel powder metal parts have been produced for years as structural parts where bright appearance, high ductility, resistance to galling and corrosion resistance are necessary, and are vital in filters for resistance to corrosion by specific media.

High-Strength, Low-Alloy Steel Powders: In spite of attendant difficulties in testing, strength values of SAE 4630A prealloyed powders are excellent. A single pressing at 40 tons per sq inch and sintering for 30 minutes at 2100 F yields tensile strengths of about 74,600 psi. Re-pressing brings this tensile strength up to 100,000 psi, and a second sintering treatment raises the tensile strength to 140,000 psi. Highest value of tensile strength obtained for multiple treatments was 171,000 psi. Because of the high hardenability of these steels, these high values are not limited to tensile specimen size, but can be reproduced in large compacts.

Carbon contents of these specimens were in the range of 0.21 to 0.30 per cent. Higher hardness can easily be obtained by raising the carbon content.

Proof of the capabilities of a powder is in a successful commercial application. The Keystone Carbon Co. has produced gears for high-pressure hydraulic pumps manufactured by the Hydreco Div. of New York Air Brake Co. The gears in Hydreco's pump are il-

Table 1—Typical Properties of High-Strength Steel Parts Made of SAE 4630A Powder*

Apparent density, per cu cm	7.5
Ultimate tensile strength, psi	115,000
Yield point in tension, 0.2 per cent offset, psi	85,000
Elongation in 1 inch, per cent	1.5
Yield point in compression 0.2 per cent offset, psi	80,000
Compact hardness, Rockwell	A65-C30
Particle hardness, Rockwell	C50
Modulus of rupture, psi	195,000
Radial crushing strength, psi	250,000

*Parts produced by Keystone Carbon Co

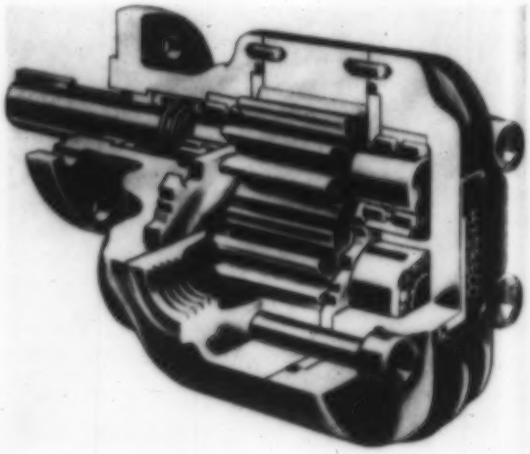


Fig. 1 — Hydraulic pump made by Hydreco Div. of New York Air Brake Co. showing powder gears produced by Keystone Carbon Co.

HOWELL MOTOR BRIEFS

Quick facts for those who apply and specify electric motors

Rerated Motors: Both *smaller* . . . and better!

The compactness of the NEMA-rerated frame sizes has been enthusiastically received by designers generally. This new, smaller, cooler, and lighter motor has been designed *especially* to meet the new demands in *modern* machine requirements.

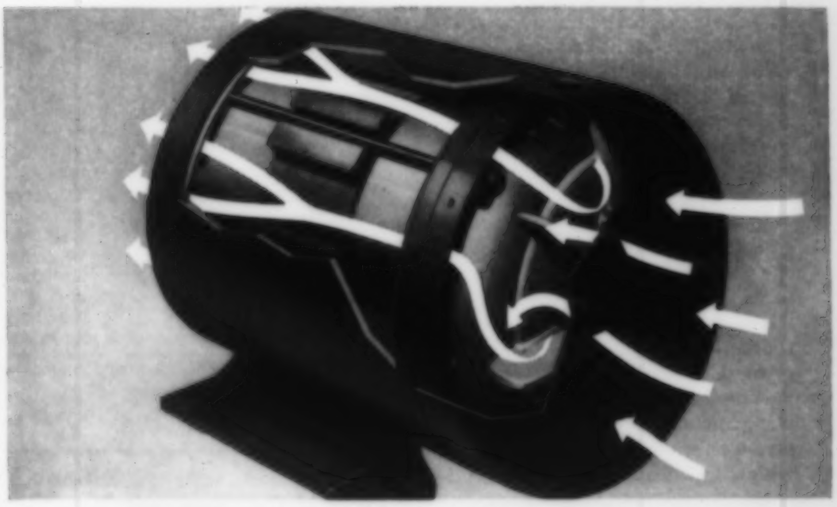
The problems of restricted space are more easily solved, together with easier installation in hard-to-get-at places. Handling is easier. Freight costs are reduced.

Howell's years of design experience, plus the scientific advances in insulation and other vital materials, have resulted in the new *Series 100* motors, often described as "the best industrial motor on the market!"

The resulting *Series 100* motors are not only smaller and lighter than their horsepower equivalents in the old frame sizes, but run cooler and allow Howell engineers more leeway to meet special requirements.

Note and compare the features of these new motors. Three points for comparison are discussed briefly at right, with the Howell *Series 100* totally enclosed fan-cooled motor used for illustration. Other features: Shock resistant steel frame; easy access, diagonally split terminal box; Mylar-insulated slot cells; and vinyl acetyl-covered wire. A compact, vibration resisting, trouble-free winding is assured by two dip and bake cycles, after stator preheating.

The *Series 100* open drip-proof motors are similarly outstanding. Howell's exclusive new stator design works heat-dissipation miracles here, too, and versatile, high stability copper-bar rotors are standard throughout the line. Bearings in the open motors, while not cartridge-type, are double-shielded and sealed in the end-plate cavities by dust-tight inner caps. Howellube greasing system provides positive lubrication and ease of maintenance.



Good ventilation — one key to better design. "Cooler running" means longer motor life. Howell's new stator construction includes wide ventilation slots around the perimeter of the laminations. The steel frame completes the ducts which provide 50% more contact between the cooling flow of fan-driven air and the main source of heat, the stator, than ever before possible in any standard motor.

Fully protected bearings last longer. Dirt can't enter Howell's cartridge-type, double shielded bearings, either from inside or outside the motor. Cartridge remains sealed even when the end-plate is removed.

Copper-Clad rotors have better heat conductivity, more stability at high temperatures and greater design flexibility to meet special requirements than die-cast aluminum rotors. Howell uses copper exclusively.

Series 100 enclosures: totally enclosed fan cooled, open drip-proof, splash-proof and weather protected, sanitary, explosion-proof, and totally enclosed non-ventilated.

Write for new Bulletin N-100-R

HOWELL MOTORS

HOWELL ELECTRIC MOTORS COMPANY, HOWELL, MICHIGAN

PRECISION-BUILT MOTORS FOR INDUSTRY SINCE 1915 lustrated in *Fig.* 1. Typical properties of high-strength steel parts produced by Keystone Carbon Co. from SAE 4630A powder are listed in *Table* 1.

Some highlights of this important successful application of powder metallurgy for hydraulic pump gears are:

1. Powder-metal gears from 4630A have replaced gears cut from bar stock and heat treated.
2. Gear runs with a dynamic loading of 2290 pounds, with a gear tooth stress of 44,000 psi.
3. Performance of powder-metal gears equals or excels that of cut gears.
4. A powder-metal gear has never failed, even when overloaded to the point where the shaft failed in torsion.
5. Finish of the powder-metal gear tooth is equal to a precision-ground finish on a cut gear.
6. Powdered-steel gears have 80 per cent of the radial crushing strength of cut-steel gears, which is adequate for the application.

The clinching argument for the gears produced from 4630A powder is that gear costs have been cut by 20 per cent with a simultaneous improvement in performance of the pump.

Prealloyed Stainless Steel Powders: A large variety of stainless steel powders have been produced, but only a few have been made in large enough quantities to be considered standard. The standard powders are Types 302B, 316, 318, 318Si, and 431.

A summary of their sintered properties is presented in *Table* 2. These properties were determined for sintering in hydrogen. Kalish and Mazza have shown that sintering in cracked ammonia would raise tensile strength values and lower ductility. Tensile strengths reported in *Table* 2 approach values for wrought steels, and elongations are higher than normally achieved with parts made from ferrous base powders. Particularly, the high elongations mean that articles can be made more porous with some retention of ductility.

Micro Metallic Corp. makes use of these excellent tensile properties to produce filters. Filter sheet from stainless-steel powders is made in sizes up to 18 by 72 inches in a wide variety of pore openings, and is fabricated by cold-forming and welding into a variety of shapes. Two filters so produced are illustrated in *Figs.* 2 and 3.

A few of the many bushings and parts made from prealloyed stain-

Table 2—Properties of −100 Mesh Sintered Stainless-Steel Powders

Vasco Type	Compacting and Coining Pressure (ton per sq in.)	Sintering and Resintering Temperature† (F)	Tensile Strength (psi)	Elongation in 1 Inch (per cent)	Final Density (gm per cu cm)
302B	40-0	2200	25,500	8	5.59
	40-40	2200-2200	54,000	20	6.23
	40-0	2300	41,500	15	5.90
	40-40	2300-2300	74,500	26	6.49
	50-50*	2300-2300	87,000	32	6.79
316	40-0	2200	25,500	8	5.77
	40-40	2200-2200	46,500	18	6.37
	40-0	2300	39,500	13	6.02
	40-40	2300-2300	60,500	20	6.60
	50-50*	2350-2350	76,000	31	7.00
318	40-0	2200	20,500	2	5.89
	40-40	2200-2200	35,500	4	6.53
	40-0	2300	27,000	7	5.91
	40-40	2300-2300	49,500	16	6.64
	50-50*	2350-2350	67,500	28	7.01
318 Si	40-0	2200	25,500	3	5.61
	40-40	2200-2200	39,500	5	6.20
	40-0	2300	45,000	7	5.95
	40-40	2300-2300	62,000	16	6.50
	40-40	2350-2350	92,000	31	7.00
	50-50*	2350-2350	91,000	36	7.15
431	40-0	2200	32,500	3	5.53
	40-40	2200-2200	48,500	7	6.05
	40-0	2300	37,500	3	5.79
	40-40	2300-2300	53,000	8	6.21
	50-50*	2300-2300	60,500	10	6.42

*Optimum properties for each grade. †Sintering and resintering times are 45 minutes at temperature in dry hydrogen.

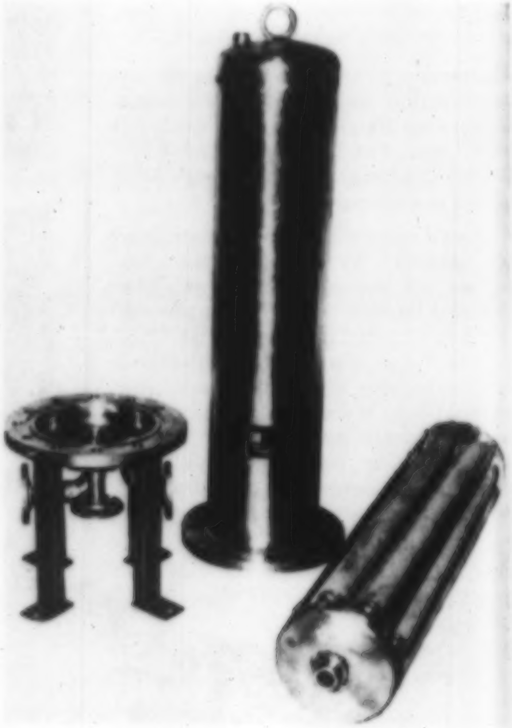
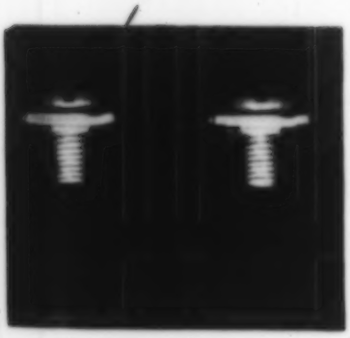


Fig. 2—Stainless-steel filter made by Micro Metallic Corp. to filter 75 gallons per hour of high-viscosity byproduct in a petroleum refinery. Filter element has 18 sq ft of filter area with a mean pore size of 65 microns. These filters will withstand 50 psi differential pressure in either direction without rupture



"Bolt-on" type breaker completes the Westinghouse Quicklag line—offers a two-pole Quicklag breaker for every application.

"Plug-in" type breaker is firmly gripped by a female line terminal clamp plus pressure contacts on the load end of the breaker.

New!

Two-pole common-trip Quicklag® breakers —"bolt-on" or "plug-in"

Whatever your choice of mountings, the new Westinghouse two-pole, common-trip Quicklag circuit breaker can now give you more flexible and efficient protection for small-wire general lighting and branch circuits. Available in 15-50 ampere ratings—120/240-volt—for a-c circuits in loadcenters, panelboards, individual applications.

Common-trip bar opens both poles simultaneously with an overload on any one pole. Single handle indicates "trip", "on" or "off". All ratings listed by Underwriters' Laboratories, Inc.

Thermal-magnetic tripping elements, De-ion® arc quenchers, a proven quick-make, quick-break mechanism, and non-welding silver alloy contacts—all combined in electrically isolated compartments—assure protection against small overloads, instantaneous magnetic action against short circuits, and longer operating life. Call your Westinghouse representative, or write Westinghouse Electric Corporation, P. O. Box 868, Pittsburgh 30, Pa. J-30184

YOU CAN BE **SURE**...IF IT'S

Westinghouse

less steel powders by Amplex Div. of Chrysler Corp. are shown in *Fig.* 4.

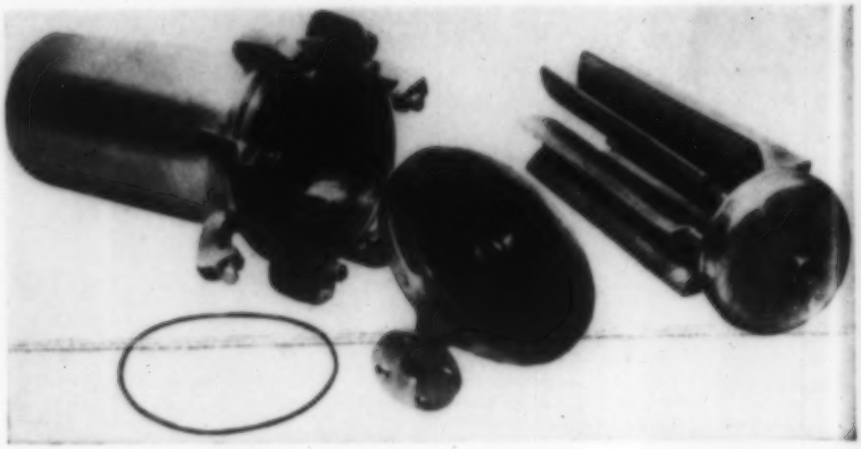


Fig. 3—Stainless-steel filter produced by Micro Metallic Corp. to remove 12-micron particles from a liquid. The bayonet elements will withstand maximum differential pressure of 150 psi from outside to inside

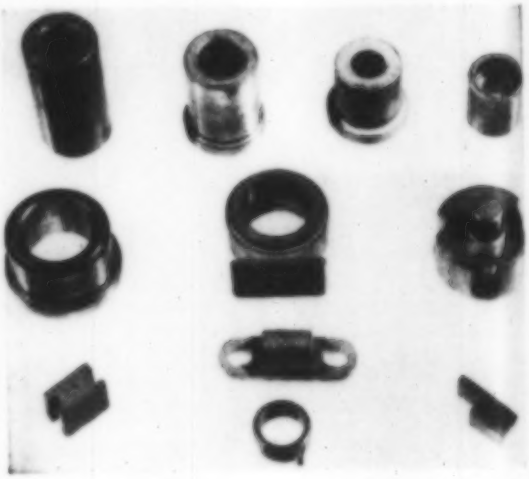


Fig. 4—Typical stainless-steel powder parts as produced by Amplex Oilite Div. of Chrysler Corp.

Stainless-Steel Powder Produced by Intergranular Corrosion: Although the powders just described are produced by a water jet disintegration process, prealloyed stainless steel powders have been produced for a long time by the intergranular corrosion process. These powders were probably the first truly prealloyed steel powders produced.

Principle involved in producing this powder is to heat treat stainless steel sheet stock, so that all of the carbides are precipitated at the grain boundaries, making them susceptible to corrosive intergranular attack. With suitable reagents, the grain boundaries can be dissolved, leaving the original grains as powder. Powder size can be controlled by controlling grain size of the sheet. Therefore, this method of making powder can readily be adapted to the production of a large proportion of fines, which are more difficult to produce by atomization processes. There are some limitations to the intergranular corrosion procedure, in that the stainless-steel compositions have to have the capacity to precipitate carbides at the grain boundaries. This becomes increasingly more difficult as the composition is changed to promote the stabilization of the carbides, as in Type 318 stainless steel.

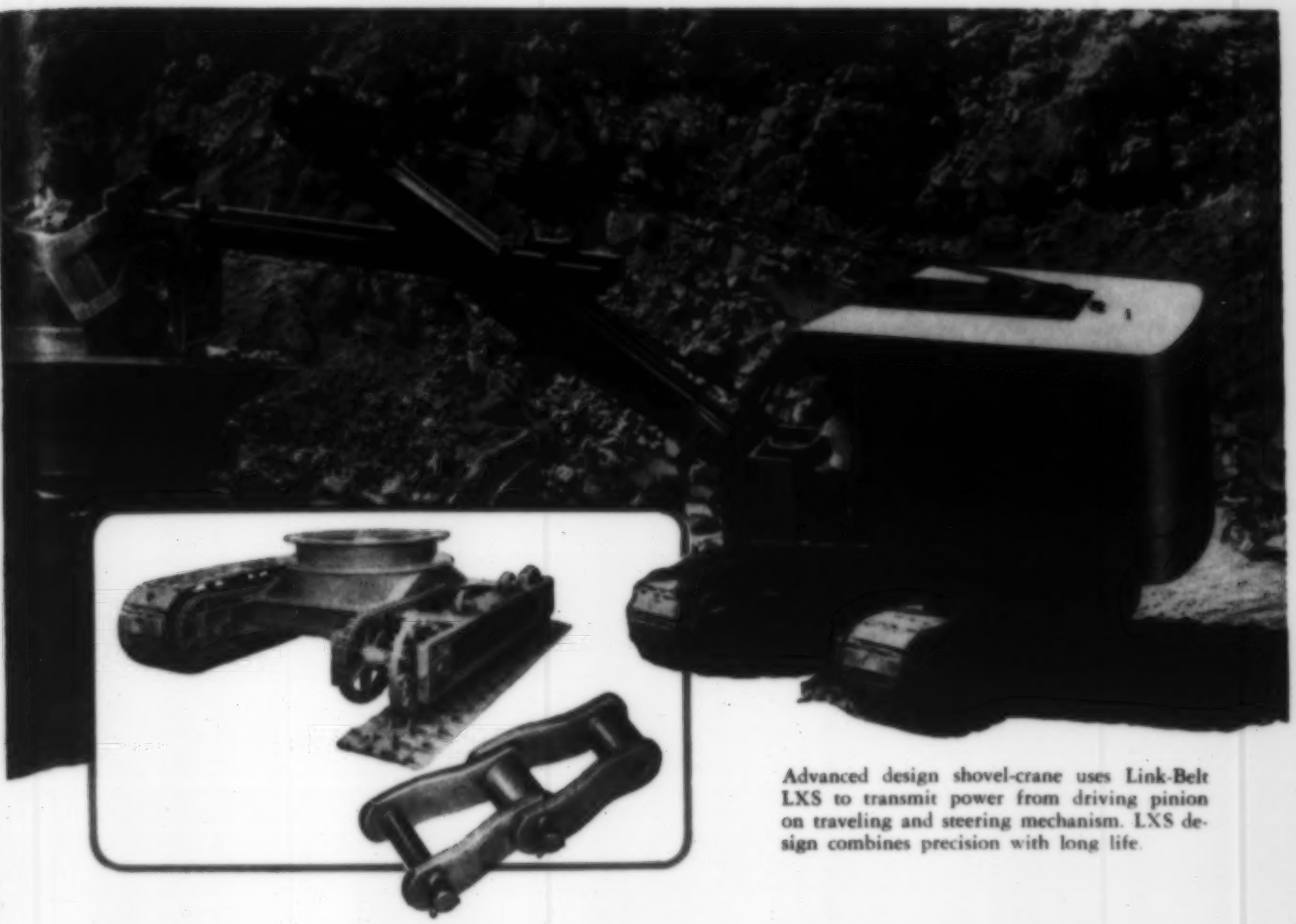
A fine powder of the 18 per cent chromium, 8 per cent nickel type was produced experimentally by the intergranular corrosion method. This powder is a low-carbon Type 302. The tensile results obtained with two different treatments are listed in *Table* 3. Strengths are equivalent to those obtained with the Type 302B reported previously. Ductility may be somewhat greater due to the fineness of the powder.

Table 3—Properties of Stainless-Steel Powders Produced by Integranular Corrosion

Treatment	Yield Strength, 0.2 per cent offset (psi)	Tensile Strength (psi)	Elongation in 1 Inch (per cent)
Pressed at 40 tons per sq in.; sintered 45 minutes at 2250 F in hydrogen	18,600	40,900	21
Same as above but re-pressed and resintered	18,400	54,700	27

By the intergranular corrosion process, a stainless steel powder can economically be produced with a large amount of fines. The powder has excellent tensile properties for structural parts, and can provide the high percentage of fines necessary for the manufacture of some filters.

From a paper entitled "Prealloyed Steel Powders and Their Applications" presented at the 11th Annual Meeting of the Metal Powder Association in Philadelphia, Pa., May, 1955.



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For heavy-duty, exposed drives-- it's LINK-BELT LXS chain

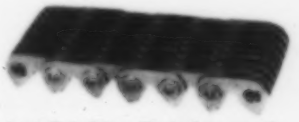
LINK-BELT offers the chain that's best for every drive and conveying job

Accurate sizing of pins, bushings and pitch holes in Link-Belt LXS chains assures a tight fit of mating parts. This plus many other important features promotes longer chain life. That's why they are so widely used for exposed drives subject to repeated heavy loads and high impact.

Similarly, for other types of power transmission and conveying, Link-Belt builds chains with the characteristics required by the job. And it's this completeness of line that gives you the *right* chain for *your* requirements.

Ask your nearest Link-Belt office for the facts on the complete Link-Belt line of chains and sprockets, including roller and silent chain drives.

No ONE chain serves every purpose -- get the RIGHT one from Link-Belt's *complete* line



Link-Belt Silent Chain for smooth, high-speed drives from fractional to thousands of horsepower. Preselected stock drives to 50 hp.

Precision Steel Roller Chain combines high hp with light weight for drives and conveyors. Single and multiple widths, ⅜ to 3″ pitch.

Double-Pitch Precision Steel Roller Chain for conveying and power transmission applications.

S-815 flat-top conveyor chain—economical, sturdy, reliable, easy to detach and keep clean.

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Helpful Literature

(*Continued from Page* 212)

recommended practices on hydraulic packings and seals, examples of code identification, sample circuit using JIC symbols, glossary of terms and other related information.

38. Fluid Control Valves

Imperial Brass Mfg. Co.—Needle, toggle, packless diaphragm, plug type, blowdown, test and Kwik-Disconnect valves for control or regulation of flow are subject of 12-page illustrated bulletin 3037. Controls are designed for use in compressed air, vacuum and liquid service at working pressures to 500 psi in certain types.

39. Casting Process

Howard Foundry Co.—"The Ellis Casting Process" is title of 4-page illustrated bulletin which describes this method for producing precision microwave fittings and electronic components of aluminum and magnesium alloys.

40. Fluid Filters

Marvel Engineering Co.—12-page illustrated bulletin "Marvel Synclinal Filters" gives data on units for filtering hydraulic oils, coolants and lubricants. Sump and line types are available in several sizes with capacities ranging up to 100 gpm. Actual mesh size of the Monel wire cloth used in filters is shown.

41. Sealed Casters

Albion Industries, Inc.—Specifications and design features of the new Albion line of sealed casters are contained in 4-page bulletin 2003. Light, medium and heavy duty types are included with capacities ranging to 2000 lb. Sectional drawings show design of seals which exclude dust, dirt and moisture and assure permanent lubrication.

42. Hose & Fittings

Aeroquip Corp.—Collection of six data sheets and bulletins gives complete design data on line of flexible hose lines with detachable reusable fittings. Described is a self-sealing coupling that replaces two shut-off valves because it seals automatically when line is disconnected.

43. Industrial Products

Wayne Pump Co., Industrial Div.—Briefly described in 4-page illustrated folder "Serving Industry" are air compressors; air, water, oil, grease and cooling liquid hose reels; hydraulically operated dock leveler; truck lift; platform lift; cross-over bridges; and dispensing and transfer units for industrial fuels, lubricants.

44. Ferrous Castings

Belle City Malleable Iron Co.—Racine Steel Castings Co.—"Cost Conscious?" is title of bulletin No. 14 which contains concrete suggestions and examples on the use of ferrous castings. Ways in which iron and steel castings can make stronger, better functioning and better appearing parts at minimum labor and material cost are described.

45. Insulating Sleeving & Tubing

Owens-Corning Fiberglas Corp.—Grades and performance characteristics of Fiberglas sleeving and tubing are tabulated in 4-page illustrated bulletin. Materials provide Class B performance in class A applications.

46. Stepping Switches

Automatic Electric Co.—The suitability of telephone type stepping switches for a wide range of functions in computors is discussed in 2-page bulletin RH6. Leaflet cites use of type 14 rotary stepping switch in the Berkeley model 1452 digital recorder.

47. Rotary Pumps

Viking Pump Co.—Special applications of Viking rotary pumps are described in 16-page catalog section J. Descriptive data and specifications cover coolant pumps in 5 to 35 gpm ratings; fire truck pumps in up to 200 gpm capacities; a fuel pump of 26 gph capacity; a chemical pump with dual ratings of 9.6 and 7.6 gpm; and dry cleaner's pumps with deliveries of 20, 35 and 50 gpm. Performance graphs are provided.

48. V-Belt Drive Engineering

Fort Worth Engineering Co.—V-drive selections, using new horsepower rating and improved rating techniques as adopted by the Multi-V-Belt Drive and Rubber Mfg. Assn., can be made quickly and accurately with the No. 50-B Guide. This bulletin contains simplified formulas and engineering data on wide range of V-belt drives.

49. Cold-Finished Steel Bars

LaSalle Steel Co.—Super La-Led cold-finished steel bars are subject of 4-page illustrated bulletin "New Super La-Led Replaces Brass." This stock is reported to have nominal machining rates that are 80 per cent faster than common screw machine steels. Physical properties and available stock sizes are listed.

50. Steam Turbines

Worthington Corp.—Single-stage steam turbines, subject of 8-page illustrated bulletin 1954C, are used for driving boiler feed pumps, forced or induced draft fans, pulverizers, mills and other equipment. They have a steel casing construction. Details of various frames, variable speed governors and features are presented.

51. Machinery Mounts

Barry Controls Inc.—How mounting machinery pays off in higher production output and lower production costs is related in 8-page illustrated bulletin 546. Summary of types of Barrymounts engineered for applications on various machines is included. Specifications for all units are in contents, as is a selector chart.

52. Motors & M-G Sets

National Pneumatic Co., Holtzer-Cabot Motor Div.—Catalog MO-3.3 contains data on special motors, motor-generator sets and related products. Frame sizes range from direct-current servo motors of 1⅝-in. diameter to power motors of 7-in. diameter. Motors with integral gear reduction are included.

53. Indicating Controller

Foxboro Co.—Model 41A pneumatic indicating controller for control of process variables such as temperature, pressure, liquid level and humidity is subject of 12-page illustrated bulletin 5A-13. New design features are explained. Instrument provides proportioning action adjustable from ¼ to 25 per cent of scale range in addition to on-off control. Specifications are included in bulletin.

54. Control Instruments

Seely Instrument Co.—Proper applications and function for Seely temperature and pressure controls are related in Bulletin I-N-1. Covered are model PC pressure pilot control for pressures from 15 to 500 psi and model ESC temperature pilot control for applications from —40 to 700° F.

55. Cycling Timers

R. W. Cramer Co.—Timers designed to repeat a definite time cycle or sequence continuously are subject of 8-page illustrated bulletin PB-510. Program, percentage and pulse timers are covered. Time ranges and ratings, wiring diagrams, dimensions and special housings for each are included.

56. Cooling Fan Drives

Oliver Iron & Steel Corp., Berry Div.—Analysis of principal advantages of hydraulic drives for aerial cooler fans is contained in 8-page illustrated brochure FD-1. Circuit diagrams, mounting dimensions and drawings, cutaway view of construction details and data on the drive selector are among contents.

57. Machine Load Control

Machinery Electrification, Inc. — Tapering rolling mills, punch presses and milling machines are applications for the MED-2128 load control, a device which protects against damaging overloads, increases perishable tool life and detects failure. Series of data sheets LC-2.1 to 2.8 presents data on various models, specifications, application data, installation information and typical applications.

58. Thermoplastic Coil Forms

Cosmo Plastics Co.—Illustrated data sheet describes Auto molded thermoplastic bobbins, produced in either self-extinguishing acetate for average temperatures or nylon for higher temperatures. Sizes range from ¼ to 1½ in. core length.

59. Stainless Fasteners

Allmetal Screw Products Co.—8-page brochure P13A gives style and size data on stainless steel screws, bolts, nuts, washers, rivets, AN and other fasteners. Available body and head styles are illustrated.

60. Hardened Steel Ways

Coes Knife Co.—Construction, typical applications and advantages of interchangeable tool steel machine ways are described and illustrated in 4-page brochure "Coes Hardened Steel Ways." They can be engineered to order.

61. Circuit Breakers

Federal Pacific Electric Co.—16-page illustrated booklet "Selection and Application of Federal Pacific Air Circuit Breakers" covers definitions used in application of low voltage breakers, method used in determining short circuit currents and the tripping device used. Selective and cascade arrangement of breakers is discussed.

62. Vibration Isolation Material

Korfund Co.—Application of Elasto-Rib, a rubber and cork damping material for the control of transmitted vibration and noise, is described in 4-page illustrated folder K5A. It is used without bolting to the floor. Various types of Elasto-Rib dampers, including Lev-Elasto machine-leveling damper, are detailed. Loading charts and specifications are included.

63. Nylon Pressure Tubing

Polymer Corp. of Pennsylvania—Uses for Nylaflow flexible nylon high pressure tubing are in air, process, coolant, fuel, oil, lubricant and hydraulic lines are subject of 6-page folder. Tubing's properties, advantages, cost, installation data and sizes available are presented.

64. Analog Instruments

George A. Philbrick Researches, Inc.—Representative selection of electronic analog computing components for synthesis and analysis, planning and plotting, and proving and improving is briefly described on illustrated data sheet

65. Nickel-Copper Alloy Steels

International Nickel Co.—48-page well-illustrated booklet "Nickel-Copper High Strength Low Alloy Steels" uses words and pictures to show the wide application of these steels in transportation, bridge construction, mining, agriculture, marine equipment and other fields. Working methods, mechanical properties, compositions and availability of seven steels in this class are given. Numerous tables and charts are included.

66. Automatic Control Systems

Automatic Temperature Control Co.—How this company can assist in arriving at the right application of an automatic control system is related in 14-page spiral-bound bulletin S-10. Case histories are presented, along with scope of services in design, purchasing, construction and start-up of packaged systems.

67. High Speed Coupling

John Waldron Corp.—Dynamically balanced in both vertical and horizontal positions, the HS coupling is made for high speed applications. Illustrated 4-page bulletin No. 52 contains specifications and general data on couplings available in 19 to 100 hp/rpm.

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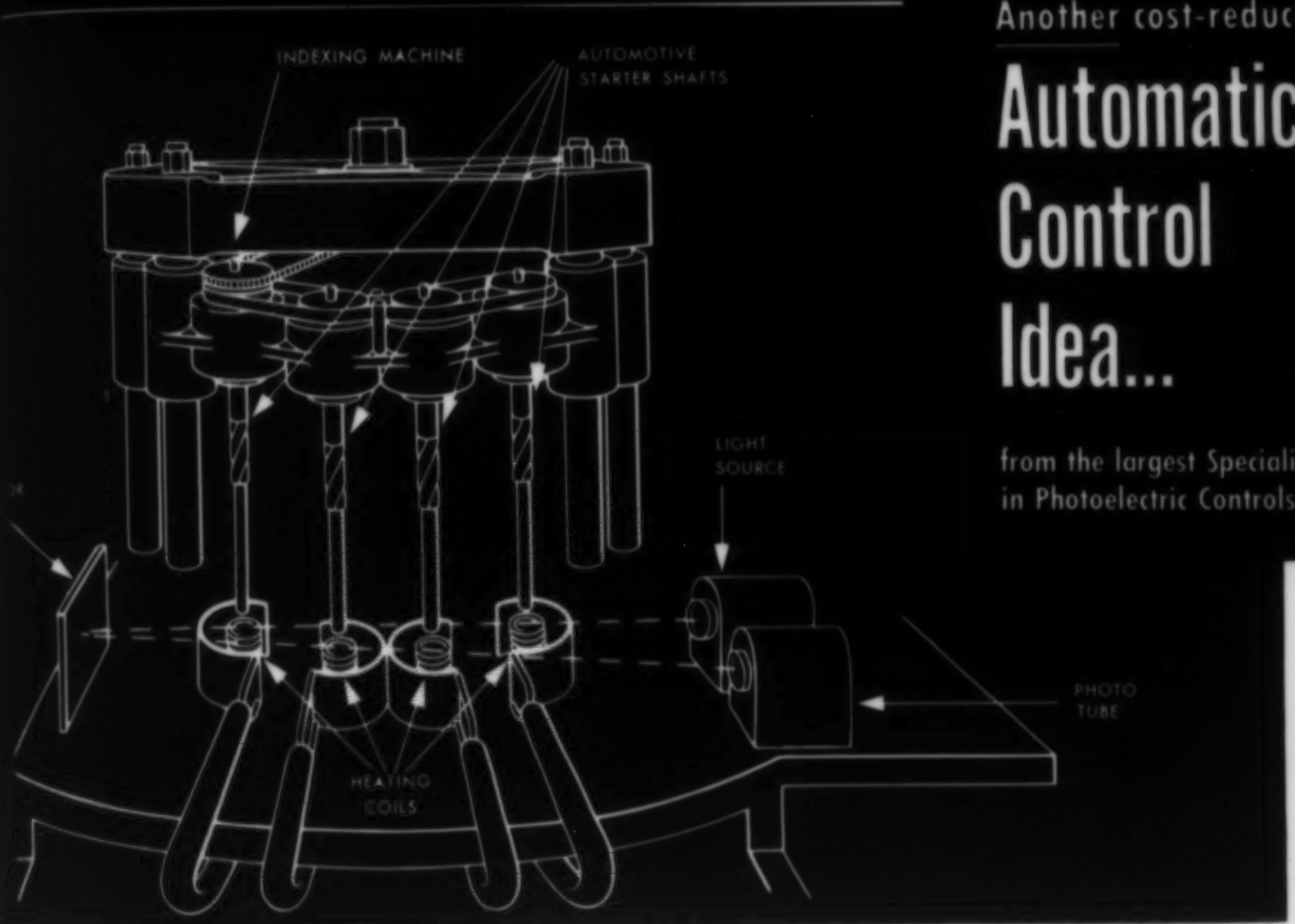

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Precise Timing and Machine Protection in High-Speed Automatic Hardening Operation

Problem: To ensure precise quality control while hardening automotive starter shafts in a special indexing machine. Also to prevent damage to equipment caused by indexing before shafts have cleared heating coils.

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Result: Precise quality control achieved through automatic timing — 1400 hardened starter shafts per hour are produced. Damage to heating coils completely eliminated.

In Photoswitch's wide variety of "ready-to-use" photoelectric controls, liquid level controls, and timers, you will find controls that precisely meet *your* requirements. So . . . for the best solution to your control problems, remember the name, *Photoswitch.*

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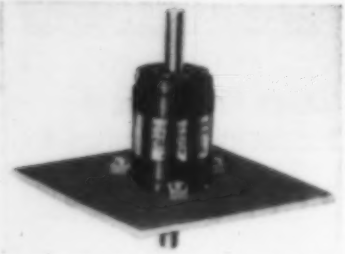
NEW PARTS AND MATERIALS

For additional information on these new developments, see Page 211

Miniature Speed Reducers

Series 106 miniature speed reducers, for use in equipment with low power requirements, are made with servo-mount ends. Rated at 1/40-hp, the reducers are available in 448 different ratios, from 1:1 to 531,441:1. Special ratios can be ordered. Use of hobbed spur gears provides smooth operation. Reducers can be clamp-mounted by using a groove and a clamp assembly, as shown, or they can be end-mounted, using four tapped mounting holes. Made by **Metron Instrument Co.,** 432 Lincoln St., Denver 3, Colo.



For more data circle MD-68, Page 211

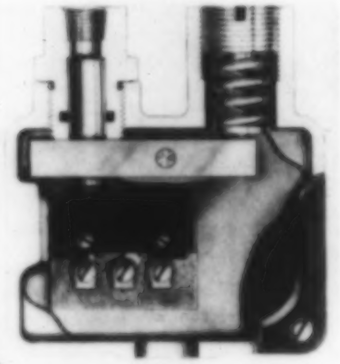
Flange Ball Bearing

Seal-Master two-bolt flange ball bearing, which permits close spacing of shafts, is available in shaft sizes from ½ to 2-3/16 in. It is zone hardened, self-aligning with locking pin and dimple, and has a labyrinth seal. Only two holes are required for mounting the bearing; it fits the diagonal bolt centers of Seal-Master four-bolt base flange units and carries the same load rating for a given shaft size. Made by **Stephens-Adamson Mfg. Co.,** Sealmaster Bearings Div., Aurora, Ill.

For more data circle MD-69, Page 211

Pressure Switch

Pressure switches for high-speed, heavy duty metalworking applications accurately sense any system pressure over an adjustable range of 35 to 12,000 psi. Proof range is 4500 to 20,000 psi. Switch will actuate an electric circuit at any predetermined point on increasing or decreasing pressure. Fixed actuation value varies from 15 to 1000 psi. External adjustment screw for field setting is locked in place. Underwriters' approved single-pole, double-throw snap-action switching element is rated for both ac and dc. Made by **Barksdale Valves,** 5125 Alcoa Ave., Los Angeles 58, Calif.



For more data circle MD-70, Page 211

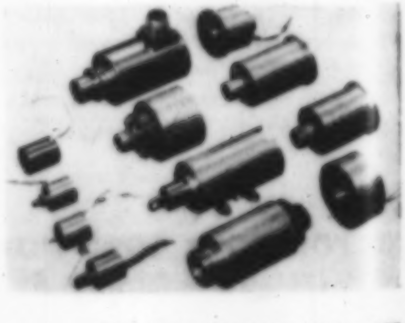
Silicone Molding Compounds

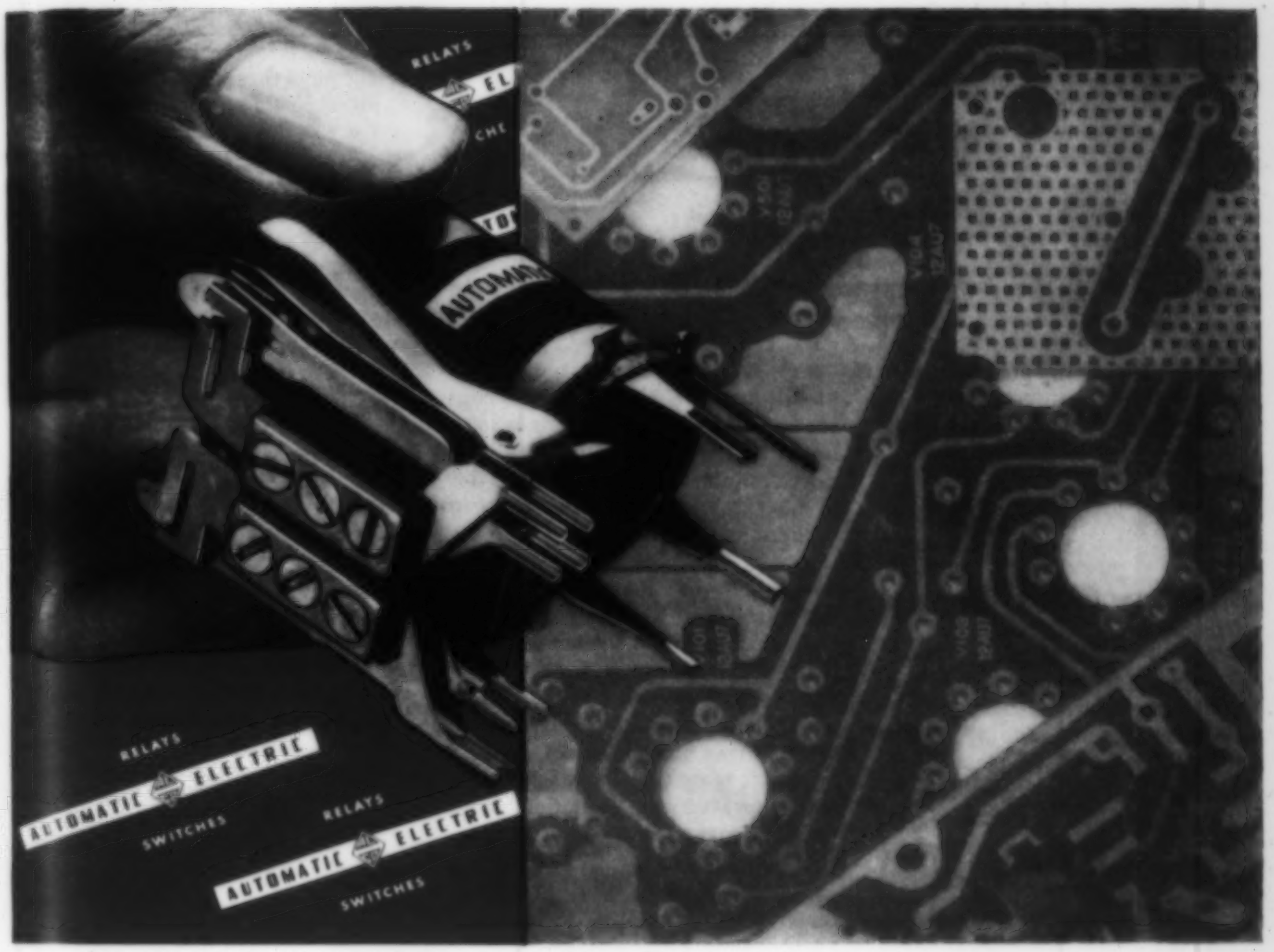
Four new silicone molding compounds exhibit good moldability and heat resistance ranging up to 660 F. Tested by continued operation at 570 F and under highly humid conditions, parts made of the materials retained excellent electrical properties at both low and high frequencies. Materials also withstand prolonged outdoor exposure. High flexural strength is developed at elevated temperatures. Glass-filled GMGA-5003 and GMKA-5004 compounds are designed for high impact resistance, together with good electrical properties. GMGA-5001 and GMGA-5002 are general purpose, mineral-filled compounds. Made by **Union Carbide and Carbon Corp.,** Bakelite Div., 260 Madison Ave., New York 16, N. Y.

For more data circle MD-71, Page 211

Direct-Current Solenoids

Line of dc solenoids includes subminiature, high-temperature and pressurized models for applications requiring precision actuators, such as hydraulic valve systems, automatic controls, switch mechanisms, aircraft electrical systems and analog and digital computers. Sol-





NOW!

dependable relays for printed circuits

Maybe you, too, have been awaiting availability of a *good* relay for direct insertion into printed circuits. Now Automatic Electric can solve your problem with a miniature relay that is just right.

120 million operations, without a single readjustment or relubrication! That's what you get from this rugged, improved Series SQD Relay, because it features a special *heavy-duty* bearing and bearing pin. Also a recess in the bearing plate retains an adequate supply of lubricant for long-term lubrication of the bearing pin.

Consider these additional advantages:

1. The sections of the terminals that insert into the printed circuit board are NOT brazed or welded into place, but are integral parts of the coil terminals and contact springs—thus preventing internal loss in conductivity or continuity.
2. Terminal design permits direct plug-in of the relay into a printed circuit board, ready to be secured in place with any acceptable soldering technique.

Usually the desired contact spring combination, or pile-up, is sufficiently large so that additional mounting (support) of the relay is not necessary.

SQD Miniature Printed Circuit Relays are available with many different contact spring arrangements, and for a multitude of applications. Springs can be made of phosphor-bronze, "Bronco" metal, or other special-purpose materials, as required.

Of course the long life, heavy-duty features of the improved SQD Relay can be had in the conventional type of plug-in relay, if regular sockets are preferred for use, whether in printed circuitry or other applications.

To get complete details, write: Automatic Electric Sales Corporation, 1033 West Van Buren St., Chicago 7, Illinois. *In Canada:* Automatic Electric (Canada) Ltd., Toronto. *Offices in principal cities.*

RELAYS SWITCHES
PRODUCTS OF THE INDUSTRIAL DEPARTMENT OF
AUTOMATIC ELECTRIC
CHICAGO

enoids have pressure-balanced armatures, stroke which is adjustable under operating pressure, high dielectric strength, class H insulation, fungus and mildew-resistant insulation, nonrotating plunger lock, and pressure sealed, high-temperature coils. Units shown range from 0.781 to 1.875 in. in diameter and weigh from 1.25 to 21 oz. They provide from 10 oz to 14 lb of push or pull through a stroke range of 0.025 to 0.375-in. Made by **Braunson Electronics Inc.,** 411 Rose Ave., Venice, Calif.

For more data circle MD-72, Page 211

Subminiature Blower

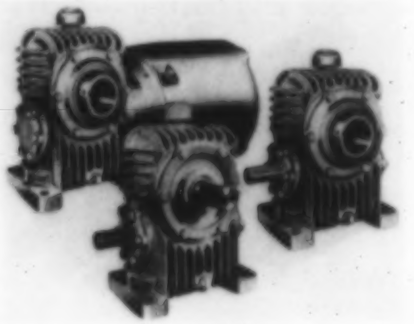
Available for clockwise or counterclockwise rotation, model L-R No. 1 subminiature blower will move 36.8 cfm of air at 20,000 rpm. Device uses a 1-in. diameter impeller. Total weight of blower and motor is less than 2.75 oz. Unit meets military specifications. Made by **Ripley Co. Inc.,** Middletown, Conn.

L-R No. 1 BLOWER
RIPLEY CO. INC.
MIDDLETOWN, CONN.

For more data circle MD-73, Page 211

Speed Reducer

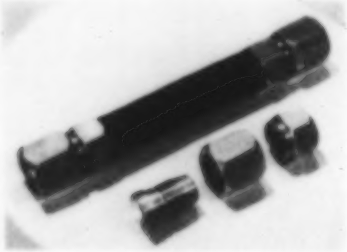
Cone-Drive 3½-in. center distance double-enveloping worm gear speed reducer has a maximum capacity of 13 hp. It is available as a standard extended shaft unit (center), shaft-mounted (right), or with either of these shaft arrangements in a motorized model (left). All models are available with worm over or under or gear shaft vertical. Cone-Drive design, incorporating short center distance, places one-eighth of all gear teeth in full-depth, continuous area contact at all times. Backlash is minimized. All models of this reducer are available in ratios from 5:1 to 60:1. Additional output speed reductions can be obtained through the use of V-belts and sheaves. Shaft-mounted motorized models can carry the driven shaft and its load in many applications to eliminate pillow blocks and other bearings. Foot mounting eliminates need for belts, pulleys, bed plates, torque arms and other conventional shaft-mounting arrangements. Made by **Michigan Tool Co.,** Cone-Drive Gears Div., 7171 E. McNichols Rd., Detroit 12, Mich.



For more data circle MD-74, Page 211

Hose and Fittings

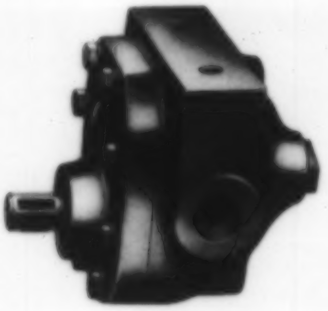
Rubber covered, single fiber braid hose is constructed of a seamless oil-resistant synthetic rubber tube, one ply of high-tenacity rayon and an oil and weather-resistant synthetic rubber cover. It can be used in service with hydraulic fluids, water, crude and fuel oils, hot oil, diesel fuels, gasoline and air in pressure range from 175 to 375 psi. Operating temperature range is −65 to 160 F. Brass reusable fittings, offered for ¼, ⅜, ½ and ⅝-in. ID hose, make skiving unnecessary. Body types available are 45-deg flare end, 45-deg flare swivel nut and male pipe thread. Made by **Parker Appliance Co.,** Tube and Hose Fittings Div., 17325 Euclid Ave., Cleveland 12, O.



For more data circle MD-75, Page 211

Hydraulic Gear Pumps

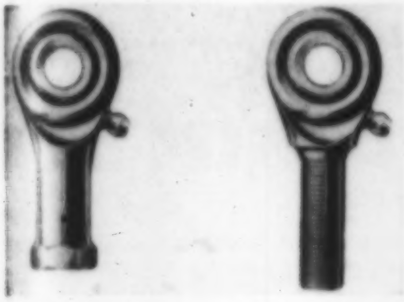
Line of gear type industrial hydraulic pumps employs standardized parts and single body casting for all pumps. Pressure loading of bearings accounts for volumetric efficiencies up to 97 per cent. Fluid pressure from the outlet side is exerted on the pump bearings to maintain the end clearance between gear and bearing faces at a thin film of oil. Pumps with capacities of 10 and 12 gpm are available at 2000 psi and 2000 rpm; a 16-gpm pump operates at 1500 psi and 2200 rpm. Units can be equipped for base, round flange or magneto flange mounting. They have keyed shafts and side ports and are assembled for rotation in either direction. Made by **Borg-Warner Corp.,** Pesco Products Div., 24700 N. Miles Rd., Bedford, O.



For more data circle MD-76, Page 211

Bearing Rod Ends

Two-piece construction with an integral lubrication fitting is employed in Spherco line of spherical bearing rod ends with bore sizes ranging from ⅛ through 1¼ in. Both male and female types are available. Forged outer member is swaged around precision steel ball to produce an inseparable assembly with high resistance to vibration and impact loading. Aircraft, standard and commercial series are available, the differences being in tolerances and materials



of construction. Made by **Spherical Bearing Corp.**, 405 Woodend Rd., Stratford, Conn.

For more data circle MD-77, Page 211

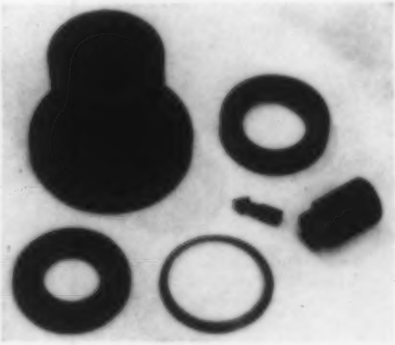
Air Line Lubricator

Airliner lubricator atomizes oil in a chamber remote from the air line and injects only oil mist into the air stream. Atomization of the oil before it reaches the air line minimizes amount of oil used, enables it to travel farther along the line than drops of oil, keeps oil density constant and allows heavier particles of oil to fall back into the oil reservoir. Operation is monitored through a transparent dome on the mist generator. Unit can lubricate any volume of air from ¾-cfm up to capacity of the line. It is adaptable to right or left-hand mounting without modification. Made by **Gits Bros. Mfg. Co.**, 1866 S. Kilbourn Ave., Chicago 23, Ill.

For more data circle MD-78, Page 211

Chlorinated Polymer

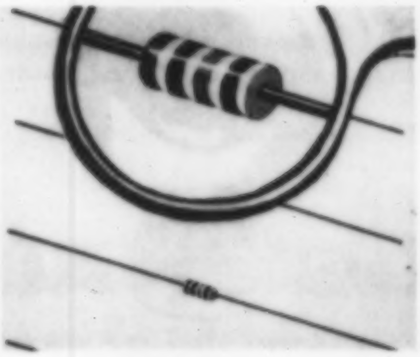
Polypenco K-51 is resistant to many alkalis and organic and inorganic acid solutions at room and boiling temperatures. Potential applications are bearings, rollers and gears used under severe corrosive conditions, and pump impellers, valve seats, gaskets, packings and similar parts for use in the chemical industry. The material can be applied to metal as a coating. It exhibits high resistance to cold flow and changes due to internal strain. Parts made of the material can be used at temperatures to 250 F, or above, if the atmosphere is nonoxidizing. Material does not absorb water. Although not a high-frequency dielectric, it can be used as a general purpose insulator throughout a wide range of frequencies. It is easily machined and at present rods up to 2 in. in diameter are available for machining. Made by **Polymer Corp. of Pennsylvania,** 126 N. Fifth St., Reading, Pa.



For more data circle MD-79, Page 211

Small Resistors

Measuring 0.140-in. long and 0.015-in. in diameter with 1-in. leads, TR molded resistors are suitable for use with transistors, diodes and other small components in miniaturized equipment. Resistors have insulating coatings and can be used with or without encapsulating compounds or casting resins. Units are available in standard RETMA, JAN-R-11 and MIL-R-11 resistance values with standard tolerances of ±5, 10 and 20 per cent from 10 ohms to 22 megohms. Maximum continuous voltage rating is 150 v ac or dc. Resistors can be operated continuously with the insulation subjected to a maximum potential of 200 v dc. Maximum continuous wattage at 70 C is 0.1-w and at 40 C is 0.2-w. Made by **Allen-Bradley Co.,** 136 W. Greenfield Ave., Milwaukee 4, Wis.



For more data circle MD-80, Page 211

Nylon Fasteners

Nylogrip screws, nuts and bolts are self-locking, corrosion resistant and insulating. Although lightweight, these nylon fasteners are tough and resilient and have tensile strengths up to 15,700 psi. They withstand continuous heat up to 300 F. Applications include electronic, chemical processing, electrical equipment, aircraft and instrumentation. Made by **Nylogrip Products,** 449 Watertown St., Newton 58, Mass.

For more data circle MD-81, Page 211

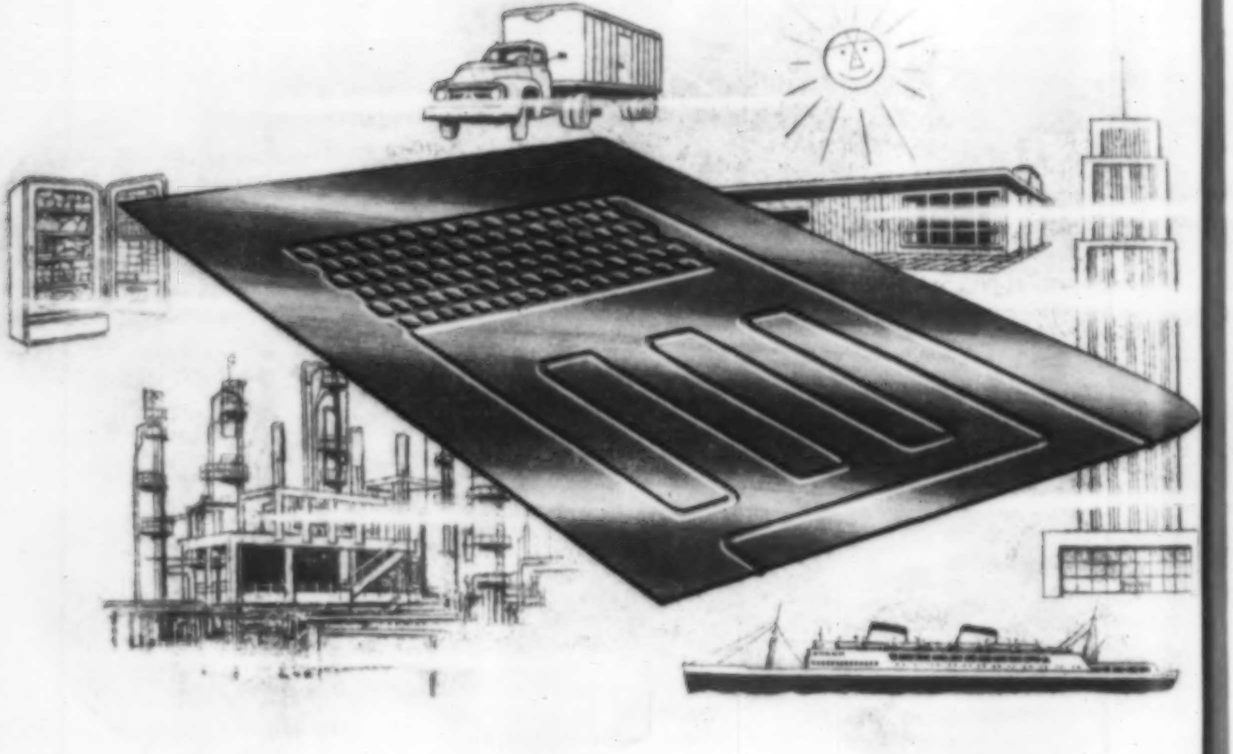
Temperature Control

Installations where temperature is to be controlled by varying the flow of gas, steam or other medium, with an air-operated valve or motor are applications of the

(*Continued on Page 224*)

Go ahead and dream! Here's the exciting new material to complement your design and engineering skill!

REYNOLDS ALUMINUM



What Tubed Sheet Is: *Tubed Sheet* is actually two sheets of aluminum metallurgically bonded together so that the heat transfer passageways are *in the sheet*. These expanded passageways route gas or liquid wherever needed with greater freedom, greater efficiency and at lower cost.

Where this new concept in heat transfer applies in transportation, chemical and petroleum, construction and many other industries:

Imagine the possibilities that *Tubed Sheet* offers in *automobile* radiators and air conditioning systems —perhaps even in future radiant heating systems for cars! Or consider *trucks* and *trailers* with refrigerating panels inside roof, sides or floor to surround cargos with constant temperatures! Take *aircraft*, too. De-icing applications in skin of planes; cockpit cooling systems; guided missiles! *Chemical, petroleum* and *petrochemical* industries can benefit from *Tubed Sheet* in air coolers and other heat transfer applications. Radiant heating panel and solar heating systems can bring the advantages of *Tubed Sheet* to the *building* and *construction* industry.

See Reynolds new network television show..."Do-It-Yourself"...Sunday evening on NBC-TV.

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Now Being Produced by Reynolds Patented Roll Bonded Process

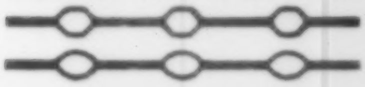
And consider this. Already design and engineering men are planning uses for this amazing new material in applications *other than* heat transfer alone! So go ahead and dream. Reynolds *Tubed Sheet* is the exciting new material that can give *your ingenuity* a chance to really operate!

How Performance and Economy Benefits Have Been Proved:

Refrigerator evaporators now being produced by Reynolds for the appliance industry point up the advantages of *Tubed Sheet*. Here are some already proved benefits:

Greater freedom in tubing pattern designs

Greater efficiency because there is no loss in conductivity as tubing is integral to sheet.



Greater economy through savings in manufacturing operations and in metal

Greater strength because there are no tubes to pull away from sheet—passageways can be flat or oval and placed closer together for extra rigidity

Reynolds *Tubed Sheet* is available with smooth surface or embossed pattern. Where desired, Reynolds *Tubed Sheet* parts can be furnished color anodized in a variety of eye-appealing colors.

Get full details on Reynolds *Tubed Sheet* now. Contact the Reynolds office listed under "Aluminum" in your classified telephone directory or . . .

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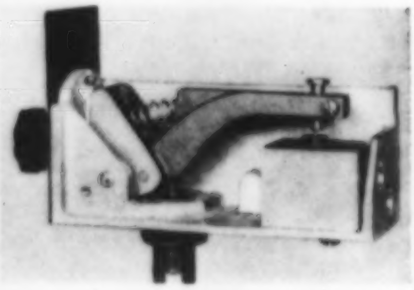
(*Continued from Page* 221)

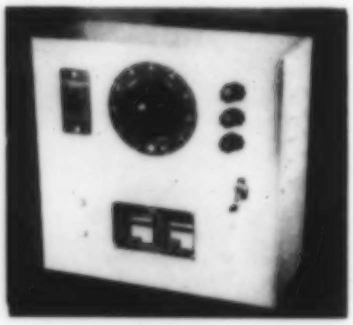
model DA pneumatic temperature control. It can be used in any pneumatic system up to 50 psi and will reduce the output or branch line pressure as the temperature increases. Available for temperatures up to 1800 F, control is offered with fixed throttling ranges, which may be specified as narrow as 5 F or as wide as 100 F. Adjustments are made with knob on front of case. Made by **Burling Instrument Co.**, 16 River Rd., Chatham, N. J.



For more data circle MD-82, Page 211

Electrical Speed Controls

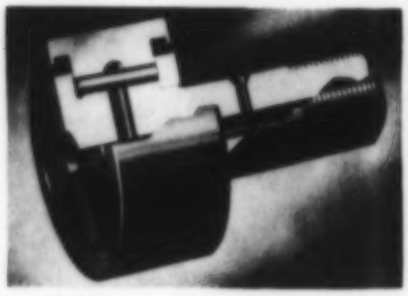
Cosmo-Trol speed controls are available with ratings from 1/10 to 29 hp for adjustable-speed operation of dc motors from single and three-phrase ac power lines. A ½-hp unit is shown. Control is made with a minimum number of components and has no moving parts. Speed range is continuously adjustable from rated speed to zero. Torque is constant throughout speed range. Overload capacity is approximately equal to that of the motor; overload protection is provided above 1/6-hp. Ambient operating temperature range is −15 to 120 F; special units are available for temperatures to 200 F. Basic unit, designed for manual operation of motor speed control, is the variable armature voltage type, which provides a wide stepless speed range on any type of dc motor in which all leads are brought out. Units up to and including 1 hp are for single-phase operation on 115-v, 60-cycle circuits; those over 1 hp are for three-phase operation on 220-v, 60-cycle circuits. Made by **Cosmo Engineering Laboratories Inc.**, P. O. Box 348, Hackettstown, N. J.



For more data circle MD-83, Page 211

Sealed Bearing

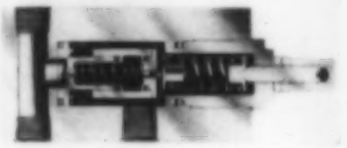
Camrol cam-follower bearing seals against contamination and retains lubricant by means of synthetic seals in outer race undercuts and the flange and stud ends of the bearing. Seals are compounded to insure size stability and to resist deterioration by any possible contact with corrosive materials. Design provides a multiple labyrinth sealing effect. Bearing is packed with an oxidation and water-resistant grease, and oil holes are provided for relubrication. Holes can be closed with plugs. A turned groove in the center of the outer raceway bore provides a lubricant reservoir without altering the shock and radial load capacity of the bearing. Made by **McGill Mfg. Co. Inc.**, 909 N. Lafayette St., Valparaiso, Ind.



For more data circle MD-84, Page 211

Relief Valves

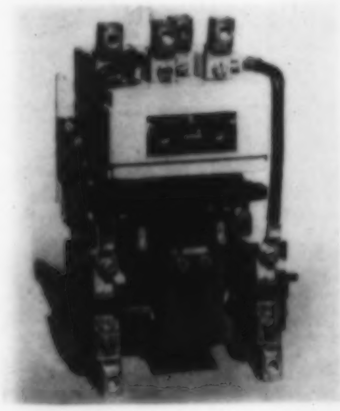
Piston-type, pilot-operated relief valves maintain pressure in hydraulic systems between 50 and 4000 psi, protecting the system, pump and other hydraulic units against damage from pressure overload. Maximum hydraulic pressure is maintained at a constant level in the system. Although the valve body has in-line ports, angle installation is possible if one port is plugged. Valves are made with female pipe connections in ¼ to 2-in. sizes in aluminum alloy or 50,000 psi tensile strength semisteel. Three pressure ranges are 50 to 1000 psi, 1000 to 2500 psi and 2500 to 4000 psi. Made by **Republic Mfg. Co.**, 15655 Brookpark Rd., Cleveland 11, O.



For more data circle MD-85, Page 211

Magnetic Starter

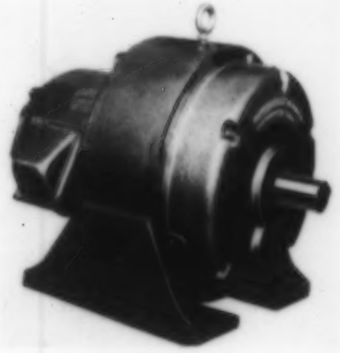
Designed for motors rated up to 100 hp, this NEMA size 4 vertical lift magnetic starter is available in reversing, multiple-speed and combination forms and can be obtained with either vertical or horizontal mechanical interlocks. It is 40 per cent smaller than previous models of the same capacity. Strongbox coil design includes a tough, cast-on plastic case for maximum protection of coil windings. A permanent air gap causes the starter to drop out when de-energized, and a bimetallic overload relay provides overload protection comparable to that available in smaller sizes. Starter operates polyphase motors in ratings of 220 v, 50 hp and 440 or 550 v, 100 hp. Made by **General Electric Co.**, General Purpose Control Dept., Schenectady 5, N. Y.



For more data circle MD-86, Page 211

Integral Gearmotors

Line of industrial integral gearmotors, designated as Rite-Lo-Speed series RDL, includes units with output speeds ranging from 25 minutes per revolution to 4000 rpm. Ratings are from ½ to 75 hp. Gearmotor shaft is directly aligned with and coupled to the electric motor shaft by a male and female connection. Starting and running are quiet and smooth in any speed range. Ball bearings are used throughout, and all gears are helical and reversible, built to AGMA standards. Made by **J. D. Christian Engineers**, 480 Potrero Ave., San Francisco 10, Calif.



For more data circle MD-87, Page 211

Protective Coating

Chemically clean metal surfaces obtained by electroplating or chemical cleaning can be preserved with Laqua protective coating. Product can be sprayed or dip-applied to part right after water rinse without drying, since it displaces the water as it deposits. A film 0.0001-in. thick has electrical resistance of 0.2-ohm at 1½ v and will not interfere with electrical connections, wiring or parts attached to a chassis that must remain in electrical contact. Product, likewise, will not hamper soldering operations or spot welding of cadmium-

(*Continued on Page* 230)

SINGLE
SPIDER GEAR
DIFFERENTIALS
by FORD INSTRUMENT are
7 ways
superior

AVAILABLE IN
four sizes: 1/8", 3/16", 1/4", and 5/16" shaft diameters
FOR EARLY DELIVERY

Ford Instrument's single spider gear differentials are engineered to highest military and commercial standards . . . to provide *extreme accuracy* in addition and subtraction, and in servo loop applications.

1—High sensitivity.
2—Minimal lost motion.
3—Precision Zerol gears.
4—Corrosion- and wear-resistant materials throughout.
5—Minimum working diameters for compactness.
6—Minimum weights.
7—Rugged, long-life design.

FREE a fully illustrated data bulletin gives performance curves and characteristics. Please address Dept. MD.

42

FORD INSTRUMENT COMPANY
Division of Sperry Rand Corporation
31-10 Thomson Ave.
Long Island City 1, N. Y.

Ford Instrument's standard components

Rate Generators
Differentials
Servo Motors
Telesyn Resolvers
Integrators
Telesyn Synchros

ELECTRUNITE SAVING 9¢ PER INCH

Clamp-type air and hydraulic cylinders made by Carter Controls, Lansing, Illinois, make many manufacturing operations automatic. Typical might be toggle operations, spring motion returns, die-set strippers, multiple holding and clamping.

One model of this low-cost, all-purpose cylinder delivers a two-inch stroke through a 2.4-inch steel air-cylinder body. For these bodies, Carter Controls had been using tubing made by a different method. A switch to Republic ELECTRUNITE® Electric Resistance Welded Tubing eliminated expensive ball sizing and burnishing for one thing. Since the ball sizing could only be done in short lengths, it was necessary to cut the tube prior to balling.

Now, Republic ELECTRUNITE Mechanical Tubing is purchased in long lengths and automatic screw machine production is practical.

The result of all this is that the air-cylinder body made of Republic ELECTRUNITE Steel Tubing shows a gross manufacturing saving of more than nine cents an inch!

Republic ELECTRUNITE Mechanical Tubing is consistently uniform in wall thickness, tolerances, roundness and surface finish. It is *precision* tubing on a production basis in every sense of the word, available in both carbon steel and in stainless steel analyses.

Write Republic your problem in any tubular or cylindrical part. Let's see where we can help you save . . . pennies or dollars.

REPUBLIC STEEL

World's Widest Range of Standard Steels and Steel Products

REPUBLIC STEEL CORPORATION
3130 East 45th Street
Cleveland 27, Ohio

REPUBLIC STEEL

Saving money interests me.
Send facts showing how your products can help.

☐ ELECTRUNITE Steel Tubing
☐ Republic Cold Drawn Carbon Corrected Bars
☐ Republic Electro Paintlok
☐ Republic ENDURO® Stainless Steel

Name____________________Title____________

Firm__________________________________

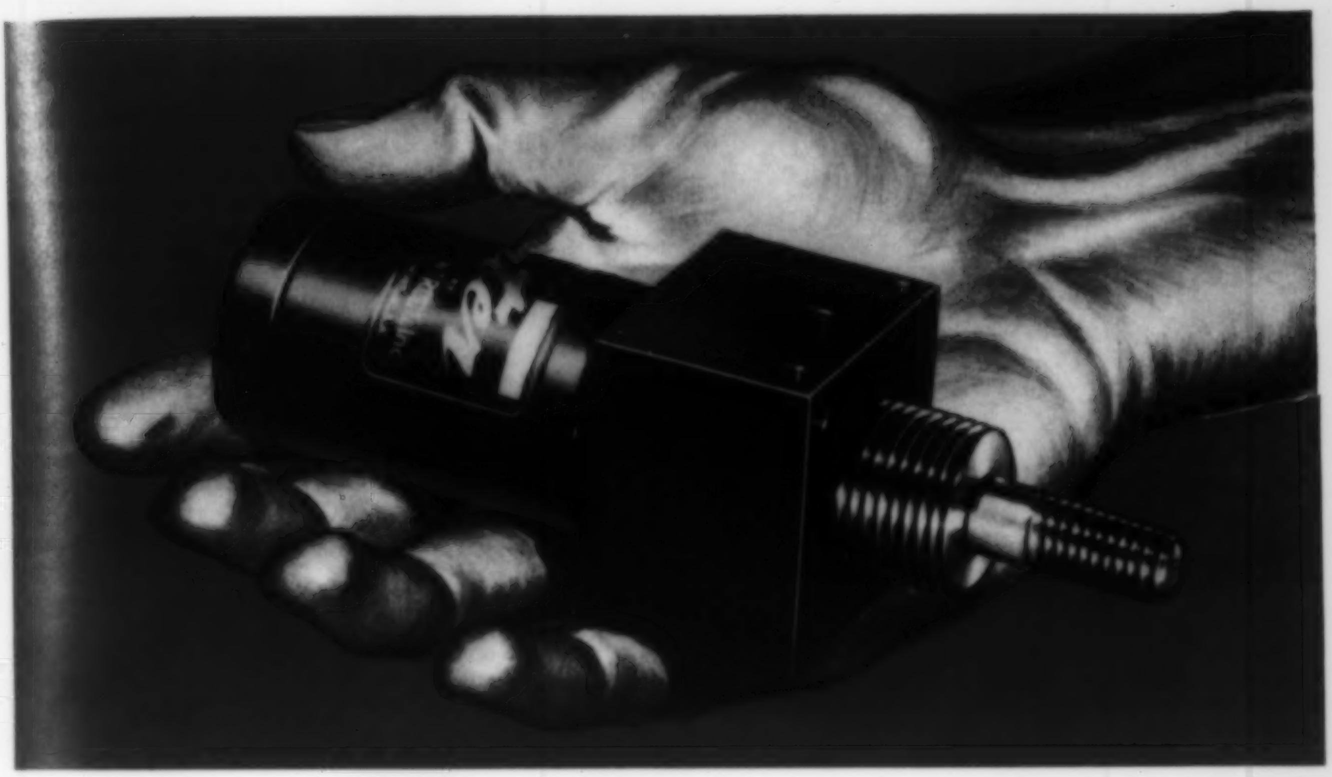
Address_______________________________

City_______________Zone____State__________

K-8735

CIRCUS
SPORTS ARENA
NOW

COSTS CUT 8%. That's the result of using Republic Electro Paintlok for these traveling poster frames, manufactured by The Yarder Manufacturing Co., Toledo, Ohio. Electro Paintlok is Republic's zinc-coated sheet steel that's chemically treated to take paints, lacquers and synthetic enamels . . . and to hold them for years. It cuts pre-paint cleaning and degreasing costs, welds readily, is easy to fabricate. If you paint on steel, write for facts about Republic Electro Paintlok.

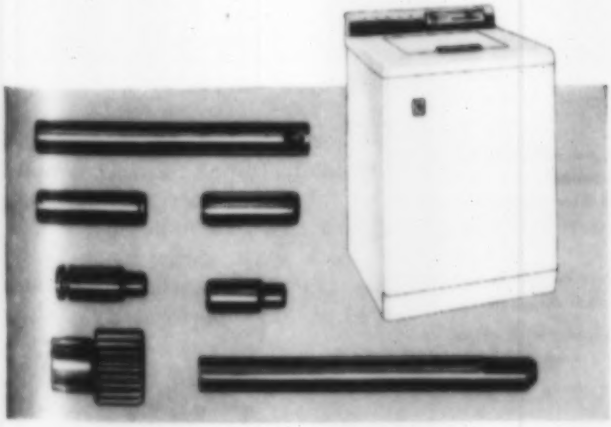


THE OLD WAY

1. Cut to length.
2. Size and burnish inside surface by pressing ball through tube.
3. Thread short lengths which are subject to distortion.
4. Cost ratio: 214

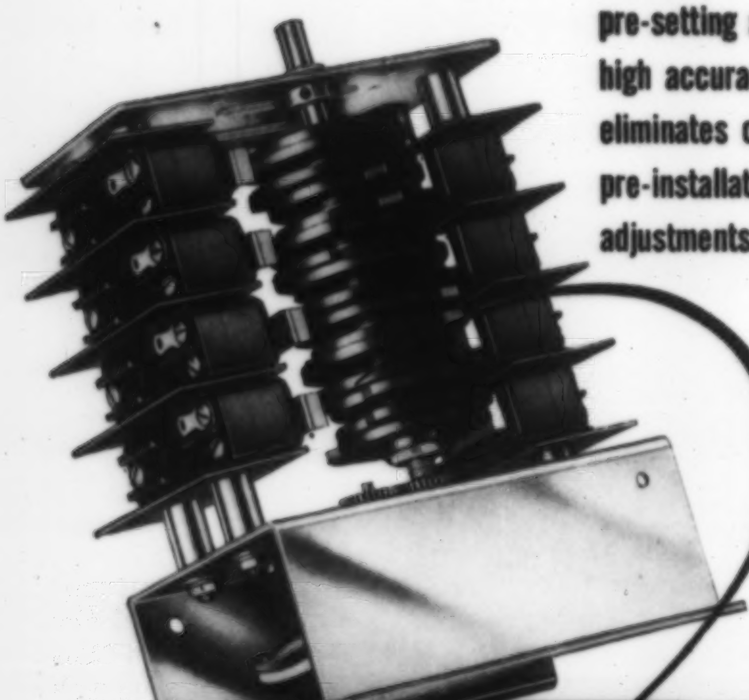
THE ELECTRUNITE WAY

1. Feed long lengths of precision ELECTRUNITE Tubing into automatic screw machine; roundness is unaffected by cutoff and threading.
2. Cost ratio: 100



NORGE REDUCED COSTS 16% on automatic-washer parts. They did it by switching to Republic Cold Drawn Carbon Corrected Steel, and eliminated a costly carburizing operation. Machinability is good and quality of the parts improved. Republic's carbon correction restores carbon lost during hot rolling, restores it right out to the edge of the bar. No need to buy oversize bars to allow for surface removal. Norge saves both metal and money. You can, too. Write Republic.

HERE, REPUBLIC ENDURO STAINLESS STEEL DIDN'T SAVE, IT EARNED! Wouldn't you spend $9 to make $40? Flxible Manufacturing Company did just that when it switched to Republic ENDURO Stainless Steel as the material for public rental lockers. Compared with previous costs for painted lockers, ENDURO cost about 9% more. But, the bright, attractive stainless steel attracts 25% to 40% added revenue. ENDURO is bright, attractive, easy to care for. You can't wear it out. Neither can high traffic locations. Republic will help you apply it advantageously, economically. Send coupon.



Factory pre-setting assures high accuracy . . . eliminates costly pre-installation adjustments

Cramer CYCLING TIMERS

The accuracy of a cycling timer depends on the exactness of the cam settings. If any one of the driving cams is incorrectly set, even to the minutest degree, the over-all program pattern or sequence of operations is changed.

Cramer cycling timers are normally supplied with all cams pre-set to customer specifications on special calibration equipment like that shown above. This pantographic principle, in effect, produces a sixteen-time enlargement of the cam, permitting extremely close setting accuracies.

While these timers can be adjusted in the field, factory setting assures highest accuracy and eliminates costly pre-installation adjustments.

This is but one of the many Cramer customer services designed to provide greater product usefulness and satisfaction at lower cost.

For full information about Cramer Cycling Timers, write for new Bulletin PB-510.

Cramer TIMING DEVICES

SPECIALISTS IN TIME CONTROL

The R. W. CRAMER CO., Inc.

BOX 6, CENTERBROOK, CONNECTICUT

13CR55

New Parts

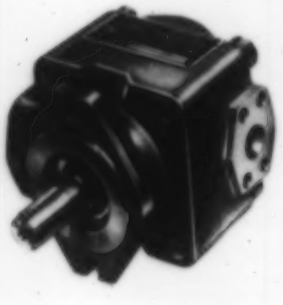
(Continued from Page 227)

plated and aluminum parts. Salt-spray resistance is very good. Developed by **Fidelity Chemical Products Corp.**, 470-474 Frelinghuysen Ave., Newark 5, N. J.

For more data circle MD-88, Page 211

Dual Vane Pump

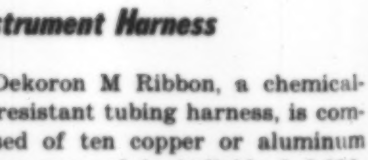
Series PFM-100 dual vane hydraulic pump is designed for high-speed direct engine drive. Built for continuous operation at 2000 psi, it has a rated capacity of 3 to 11 gpm at 1200 rpm, but it may be operated at speeds from 400 to 2600 rpm, depending upon pump size. All standard SAE and industrial mountings and piping provisions are available; port positions are flexible. Dual vane construction provides multiple fluid seals which minimize slippage and power loss. Made by **New York Air Brake Co.**, Dudco Div., 1796 E. Nine Mile Rd., Hazel Park, Mich.



For more data circle MD-89, Page 211

Instrument Harness

Dekoron M Ribbon, a chemically resistant tubing harness, is composed of ten copper or aluminum tubes encased in individual 0.020-in. thick elastomeric black polyvinly chloride sheaths, which are attached by perforated plastic



Another design feature for 'Jeep' Power Giant ruggedness

POWER GIANT

F-Head "Hurricane" Engine measures 24.81" from fan to flywheel — 30.76" from crankcase to carburetor intake.

For Compact Power...
70 horses in a 2 ft. length

Here's an engine that's small in size but a giant in power . . . the smoothest of the "fours" through superior balance. Though displacing only 134.2 cubic inches, this Jeep POWER GIANT "Hurricane" turns out up to 70 H. P. and 115 lbs.-ft. maximum torque. The proven **ruggedness** of POWER GIANT power stems from such examples of Willys **"Enginuity"** as positive valve rotators; positive filtered crankcase ventilation; statically and dynamically balanced, counterweighted crankshaft and others.

POWER GIANT engines have world-wide distribution of parts . . . and costs are reasonable because of volume production. Write today for technical bulletins.

HOW TO HOOK UP TO 'JEEP' POWER GIANT RUGGEDNESS

Here are four standard transmission arrangements. Inquire for special needs.

1 SAE BELL HOUSINGS — Rugged cast unit that can support rear of engine. A necessity for clutch and PTO.

2 POWER TAKEOFF — Direct drive; heavy duty over-center 8" clutch with gear tooth type drive. Positive engaged and disengaged positions. Close adjustment of clutch without special tools.

3 SPEED REDUCERS — Incorporates over-center clutch, PTO and reduction gear. Ratios from 1.37 to 3.9 to 1.

4 AUTOMOTIVE TYPE TRANSMISSION — Installation includes automotive type Bell-housing, clutch and remote control type transmission. An economical speed reducer, using production parts.

SPECIFICATIONS

Model	Jeep	Hurricane	Lightning
Cylinders & Head	4L	4F	6L
Cu. In. Displ.	134.2	134.2	161.0
Range Max. BHP	22-60	22-70	28-75
Range Max. Speed	1200-4000	1200-4000	1200-4000

Write for:

4 and 6-cylinder engine bulletins
Power Unit bulletin

'Jeep' POWER GIANT Industrial Engines and Power Units

WILLYS MOTORS, INC. *Industrial Engine Department* webbing. One or more individual tubes can be stripped from the ribbon without tools and without destroying the protective coating. Each tube measures ¼-in. OD with 0.030-in. wall copper or 0.032-in. wall aluminum, or ⅜-in. OD with 0.032-in. wall copper or 0.035-in. wall aluminum. Overall widths of the harnesses are 4⅛ and 5⅛ in., and they are available in lengths to 500 ft. Made by **Samuel Moore & Co.**, Dekoron Products Div., Mantua, O.

For more data circle MD-90, Page 211

Motor Speed Control

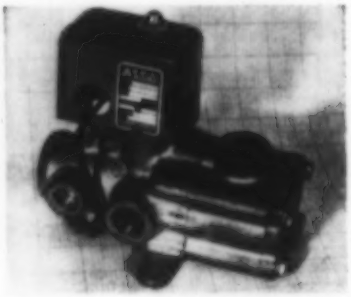
SPEED CONTROL

Type RM5 motor speed control is designed to provide stepless, reversible, adjustable-speed operation of dc shunt wound motors rated up to 1/15-hp. It operates directly from single-phase ac power lines and maintains constant torque over a wide speed range. Small motors with base speeds of 5000 to 10,000 rpm can be operated through a speed range of as much as 1000:1. Control is capable of instantaneous starting without warm-up. A delay fuse in the armature circuit affords protection against sustained overload. Control is housed in a self-ventilating and electrically neutral steel enclosure 7¼ in. high, 6¼ in. wide and 4½ in. deep. Made by **Opad Electric Co.**, 69 Murray St., New York 7, N. Y.

For more data circle MD-91, Page 211

Solenoid Valve

Piston malfunction due to binding or residual magnetism is eliminated by Bulletin 8344 four-way poppet type solenoid valve for hydraulic and pneumatic systems. Power operated in both directions, it has only three moving parts. Valve operates at a maximum rate of 850 cycles per minute. Single or dual solenoid is available, depending upon electrical circuit involved. Dual type locks into position in event of power failure. Pressure on valve disks forces them against the metallic junction of the disk and seat to provide an effective seal. Valve can operate in any position and on all standard voltages. Standard, watertight and explosion-proof models can be supplied. Dual solenoid type withstands pressures up to 500 psi, while the single type withstands 250 psi. A ⅜-in. pipe size unit is in production, with ½, ¾ and 1-in. sizes to be available soon. Made by **Automatic Switch Co.**, 391 Lakeside Ave., Orange, N. J.



For more data circle MD-92, Page 211

Shielded Ball Bearings

Torque-tube type B500DD series ball bearings combine extremely thin-section construction with nonmetallic, close clearance shields which are positively attached to the outer ring. Further sealing is not required in most applications. All exposed surfaces are cadmium plated, and full faces are provided on both inner and outer rings. Bearings provide protection from dirt, retention of the correct amount of lubricant and resistance

Let's Talk About

Sealing Service

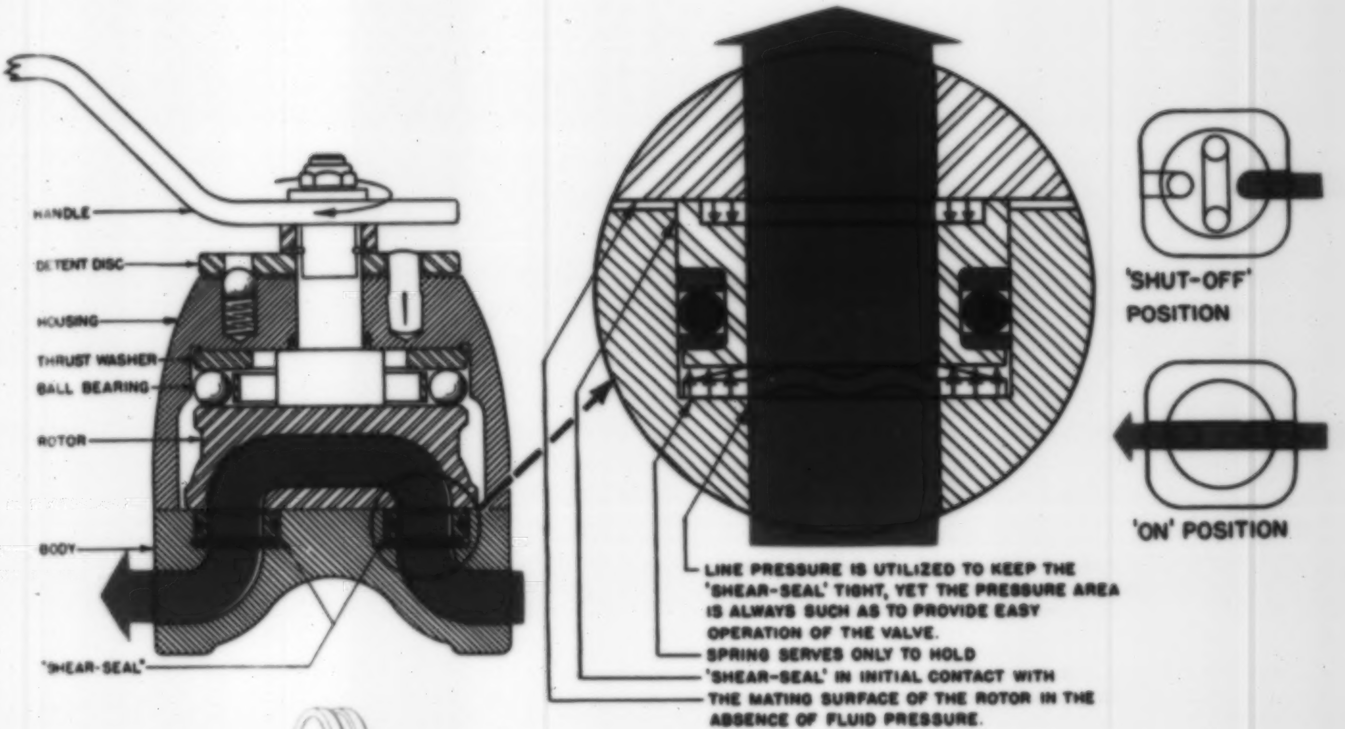
DURAMETALLIC is ready to help you with those stuffing box problems . . . we've been doing it for industry for 38 years. Experienced factory-trained sales and service engineers are located in all sections of the U.S.A.

Without charge, a staff of research and development engineers at our Kalamazoo plant are ready to help you with your sealing needs.

When seeking an answer to satisfactory sealing . . . put it up to Durametallic.

Write Today for Bulletin File No. DM-MD

DURAMETALLIC CORPORATION
KALAMAZOO, MICHIGAN


HANDLE
DETENT DISC
HOUSING
THRUST WASHER
BALL BEARING
ROTOR
BODY
"SHEAR-SEAL"
'SHUT-OFF' POSITION
'ON' POSITION
LINE PRESSURE IS UTILIZED TO KEEP THE 'SHEAR-SEAL' TIGHT, YET THE PRESSURE AREA IS ALWAYS SUCH AS TO PROVIDE EASY OPERATION OF THE VALVE.
SPRING SERVES ONLY TO HOLD 'SHEAR-SEAL' IN INITIAL CONTACT WITH THE MATING SURFACE OF THE ROTOR IN THE ABSENCE OF FLUID PRESSURE.

THE "SHEAR-SEAL" VALVE PRINCIPLE IS WELL WORTH YOUR STUDY

Cost and hydraulic control of many products have been improved through the incorporation of "Shear Seal" valves. Manual or Solenoid shut-off and selector valves will handle air, oil, water, grease, fuel and gas at pressures ranging from vacuum to 6000 PSI.

The patented "Shear-Seal" principle consists primarily of a pressure balanced, self-aligning, tubular valve seat, the "Shear-Seal," constantly in perfect contact with an optically flat porting disc, or rotor. The porting disc, or rotor, contains flow passages which are oriented by rotation of the rotor. Mating surfaces of the "Shear-Seals" and rotor are lapped to a five micro inch finish and are checked with monochromatic light waves to assure optical flatness within one light band per inch.

Rugged marcel compression springs maintain intimate contact at all times between the self-aligning "Shear-Seal" and the optically flat rotor. Positive leakproof closure is accomplished by means of this marcel spring, plus a predetermined hydraulic force on the "Shear-Seal." Thus, the higher the pressure, the tighter the seal. This controlled hydraulic load on the "Shear-Seal," in conjunction with large ball thrust bearings, is responsible for the exceptionally low handle load encountered with "Shear-Seal" valves, even at 6000 PSI operating pressures.

Actuation of a Barksdale Valve shears the fluid flow, (hence the name "Shear-Seal") and the square external corner of the "Shear-Seal" face wipes the rotor clean. Thus the sealing surfaces stay clean. Continuous intimate contact of "Shear-Seal" and rotor prevents dirt or foreign particles from entering between sealing surfaces. Dirt might otherwise hold the valve open, as with a poppet, or cause scored sealing surfaces and severe leakage, as with a conventional spool or slide valve.

Fluid flow always takes place through the opening in the center of the "Shear-Seal" rather than across sealing surfaces, (as occurs with a conventional poppet or needle valve). Sealing surfaces of the "Shear-Seal" and rotor are further protected by constant contact with each other. As a result, erosion or "wire drawing" are not experienced with "Shear-Seal" valves, even with extremely dirty, high velocity fluid.

Severe service over a period of years clearly shows that "Shear-Seal" valves improve with use because of the self-alignment and the self-lapping, wear compensating characteristics of the "Shear-Seal." Barksdale Valves actually "wear-in" where others "wear-out."

Long life and low maintenance cost have created wide acceptance in the field—indisputable proof of the soundness of the Barksdale "Shear-Seal" principle.

For the more complete story, visually explained in comic book sequence, write for "Super Seal explains the Shear-Seal principles." Included are some interesting cut-out models which further demonstrate the unusual characteristics of this valve principle.

BARKSDALE VALVES

5125 Alcoa Avenue, Los Angeles 58, California

Send FREE bulletin "Super Seal Explains the 'Shear-Seal' Principle."

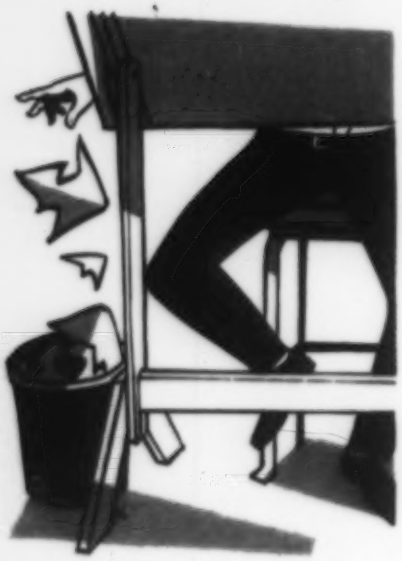
NAME ____________ TITLE ________

COMPANY ____________

ADDRESS ____________

CITY ____________ ZONE ______ STATE ________

Before You Give Up...



consider
a ball

Your wastebasket knows how a design job is going . . . "You're on the wrong track," it says when it looks like the one above. "You need a fresh approach."

"Maybe you should consider a ball . . ."

A *Universal* ball. ●

A Universal ball so tiny you can hardly see it. Or a Universal ball as big as a golf ball. There's a size for every need —including the *new* demands for today's new uses. For these days, designers and manufacturers are continually coming up with new products and new jobs for balls in every industry in the country.

From smallest to largest, Universal balls are as perfectly round as long experience, close quality control, and skillful workmanship can produce. Tolerances within 10-millionths of an inch. And we can supply just about any kind of metal you wish.

Next time your wastebasket starts working overtime, and you see where a ball might make an "impossible" job possible, call us in. Maybe we can help.

Universal Ball co.

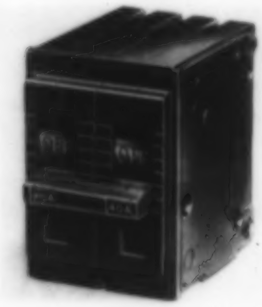
WILLOW GROVE
MONTGOMERY CO., PA.

to corrosion of exposed surfaces. Available in a range of bore sizes from 0.6250 to 2.3125-in., they have a constant inner ring width of 0.281-in. and an outer ring width of 0.250-in. Radial limit load rating ranges from 3280 to 10,150 lb. Made by **Fafnir Bearing Co.,** New Britain, Conn.

For more data circle MD-93, Page 211

Circuit Breaker

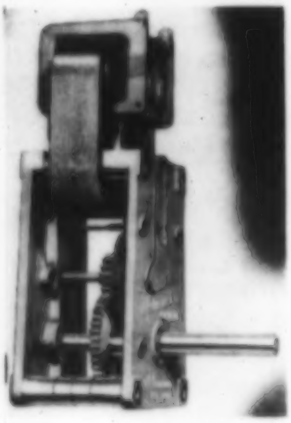
Six ratings from 10 to 50 amp for 120/240 v ac operation are available in type TQL circuit breaker, a 2-in. model consisting of two pole units with an interlocking trip mechanism assembled as a single unit. It will fit load centers or panel-boards designed for 1-in. type R or type TQL circuit breakers. Interrupting rating is 5000 amp ac. Excessive current in either pole trips both poles at once. Thermal and independent magnetic trip elements provide protection against both short circuits and sustained harmful overloads. Momentary overloads will not trip the breaker. Made by **General Electric Co.,** Trumbull Components Dept., Plainville, Conn.



For more data circle MD-94, Page 211

Gearmotor

High starting torque is provided by Super gearmotor for either continuous or intermittent operation. Output torque at 10 rpm ranges from 120 to 500 oz-in., depending on duty cycle. Output shaft can be geared to 3 rpm and up. Standard output shaft diameter is 3/16 to $^3/_8$-in., cut to desired length. Other sizes are available. Unit can be had with magnetic clutch to provide motion at output shaft only for interval of electrical contact. It operates on 115-v 60-cycle ac. Made by **Motoresearch Co.,** 1602 Junction Ave., Racine, Wis.



For more data circle MD-95, Page 211

Elapsed Time Indicator

Watertight series HD-654 elapsed time indicating meter has five digit counters which can be provided to register 0.1-minute or 0.1-hour increments to 9999.9 or hour steps to 99,999. Self-starting synchronous motors for 110 to 125-v, 60 or 400-cycle ac can operate continuously at temperatures from −55 to 85 C. Sealed 3½-in. diameter housings combine drawn steel cases and die-cast aluminum mounting flanges. Available from **DeJur-Amsco Corp.,** 45-01 Northern Blvd., Long Island City 1, N. Y.

TOTAL HOURS

For more data circle MD-96, Page 211

Electric Counter

Tamperproof, tumbler-lock reset model 6-Y-1-2-MF Productimeter registers up to 1000 counts per minute. Designed for panel mount-

ing, the entire assembly can be placed into a panel and securely fastened from the front. Hardened steel working parts are used throughout. Counter operates on 110-v, 60-cycle ac. Figures are 9/64-in. wide and 3/16-in. high. Overall dimensions of the counter are 5½ x 2 9/16 x 2⅛ in. Made by **Durant Mfg. Co.**, 1933 N. Buffum St., Milwaukee 1, Wis.

For more data circle MD-97, Page 211

Small Throttling Valve

This 6-in. high Bantam automatic diaphragm control valve provides low hysteresis and instantaneous response on service up to

1000 psi at 350 F over a 3 to 15-psi control air range. Stainless steel construction and Teflon diaphragm are standard. Direct or reverse acting, the control is available with five sizes of linear, equal percentage or quick-opening plugs, 3/16-in. and below. Made by **George W. Dahl Co.**, 430 High St., Bristol, R. I.

For more data circle MD-98, Page 211

Mechanical Integrator

Precision ball and disk integrator can be used in high-performance closed-loop servo systems and as an accurate variable-speed drive. Total ball carriage travel is 2 in. Disk is slightly over 2 in. in

(*Continued on Page* 240)

Dependability!
Precision!
Speed!....

Three Important Production Factors Presented by the DPS LINE OF ASSEMBLING EQUIPMENT

● Do you have a feeding or assembly problem? Remember that DPS stands for equipment that will bring you greater earnings, lower costs and on-time schedules . . . A complete line of modern power-driven machines that assures performance in keeping with the increased tempo of present-day production.

Give Us your Problem . . . Send Sample Assembly . . . No Obligation!

POWER SCREWDRIVING MACHINES
•
SELECTIVE PARTS FEEDERS
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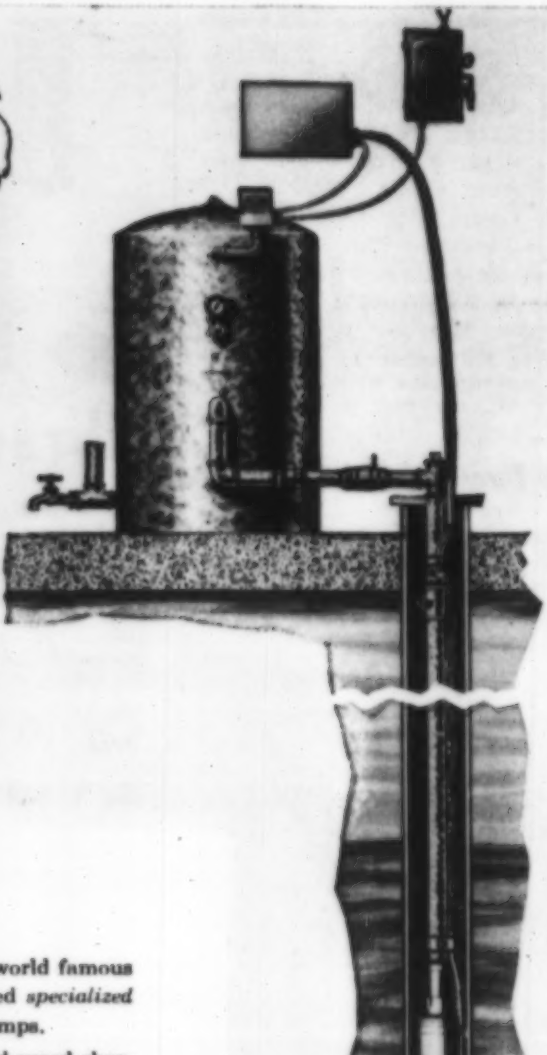
SPECIAL ASSEMBLY MACHINES

DETROIT POWER SCREWDRIVER CO.
2801-A W. FORT ST. DETROIT 16, MICH.

Jack & Heintz supplies customized



HERE WAS THE NEED

The F. E. Myers & Bro. Co., Ashland, Ohio, world famous for water systems, pumps and sprayers, needed *specialized* rotors and stators for its line of submersible pumps.

These components had to provide torque and speed characteristics *tailored* for maximum efficiency within the unique Myers pump design. They had to operate dependably, in a completely oil-filled housing, deep inside a well. Quality had to be closely controlled to meet Myers high standards.

These exacting specifications had to be fulfilled while limiting costs to provide extra value to the growing pump industry. To answer these requirements, Myers called on Jack & Heintz.

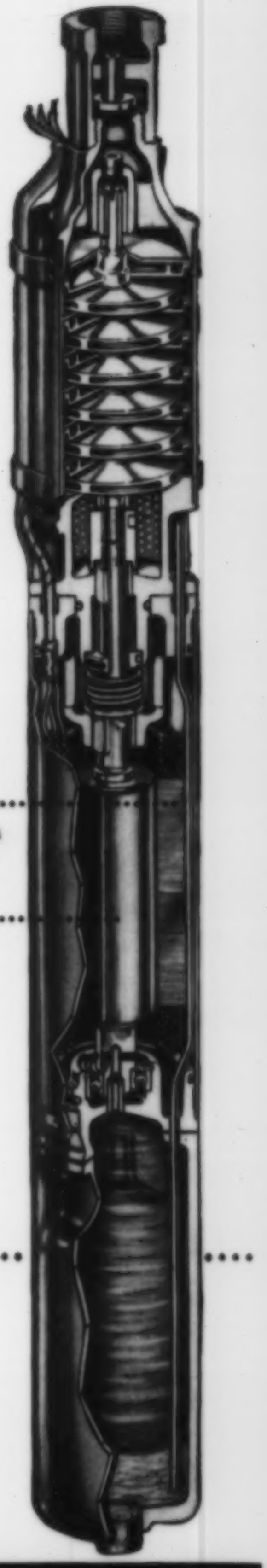
Customized ELECTRIC

motor components for

Myers

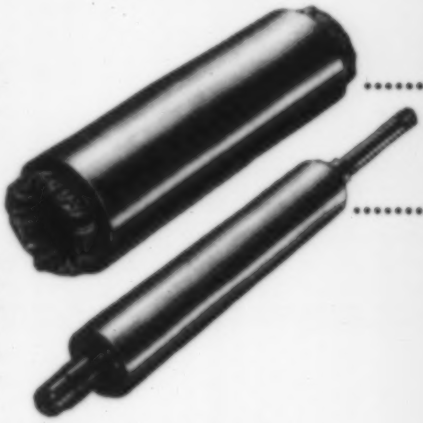
Submersible Pumps

Jack & Heintz accepted the responsibility of designing and manufacturing basic customized motor components in accordance with the typically high standards of the Myers-built pumping unit—designed to work under water for thousands of service-free hours.



STATOR

Special windings were designed to furnish the exact operating characteristics to meet the Myers specifications. Special insulating materials were developed, completely impervious to the oil in which they operate.



ROTOR AND SHAFT ASSEMBLY

The rotor was developed with the maximum amount of copper to achieve the highest possible speed at full-load torque. Silver alloy induction brazing makes it an indestructible mass. Tolerances on the rust-resistant shaft are held strictly to Myers specifications . . . with precision balancing to prevent vibration.

In addition, highly specialized methods and processes were developed by Jack & Heintz to provide manufacturing economies consistent with the needs of an expanding market for Myers submersible pumps.

DESIGN YOUR PRODUCT TO DO A JOB . . .
not to fit a motor

Avoid compromising your product design by taking advantage of an engineering philosophy that will answer your special motor needs. Design your product to do a job . . . *not to fit a motor!* Write Jack & Heintz, Inc., 17626 Broadway, Cleveland 1, Ohio.

© 1955, Jack & Heintz, Inc.

MOTORS *by* JACK & HEINTZ

ENGINEERING PRODUCTION PURCHASING

Urgent
- Improve product performance
- Reduce assembly operations
- Lower unit costs

Specify ACUSHNET for
Precision-Molded Rubber Parts

Designing a new part or product? Checking parts in present assemblies in an effort to improve product performance . . . extend service life . . . reduce assembly operations . . . lower costs?

Call on Acushnet. We've provided the solution to troublesome production, performance and cost problems in the products of innumerable manufacturers, large and small.

Custom engineered to meet the special requirements of your particular application, an Acushnet precision-molded rubber part could be the answer you've been looking for.

Acushnet

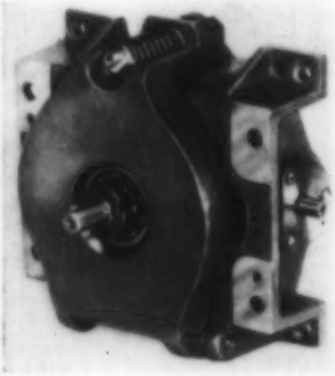
Acushnet Rubber Data Handbook sent when requested on your company letterhead. Also available; brochures on Rubber-To-Metal Bonding, and Silicone Rubber Parts.

ACUSHNET PROCESS COMPANY

Address all communications to 762 Belleville Ave., New Bedford, Mass.

New Parts

(Continued from Page 237)

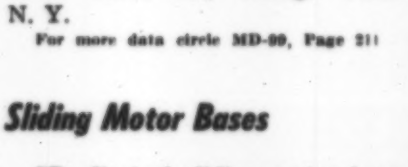


diameter. The ball carriage is positioned by an angular shaft displacement. Ball bearings are used throughout the integrator. Error is less than 0.1-per cent over most of the ball carriage range under typical disk speed and output torque conditions. Dimensions are 1¼ x 1¼ x 3¾ in. over shaft ends. Made by **Belock Instrument Corp.**, Instrument Components Inc. Div., 14-34 112th St., College Point, N. Y.

For more data circle MD-99, Page 211

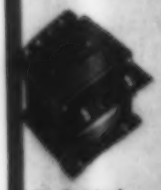
Sliding Motor Bases

SR all steel sliding motor bases are made in three types. Motor carriage of each consists of a cross member and three square steel tubes. Each base accommodates motors of two different NEMA frame sizes. When the base is used in conjunction with a variable-pitch pulley, the center tube of the carriage houses the working portion of the positioning screw and its follower nut. When base is used to control belt tension, the tube also houses a spring. Bases can be mounted in any position. Adjustable by means of a crank handle, type SQ permits rap-



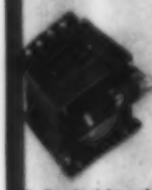
id changes in speed. Carriage travel meets requirements of any variable-pitch pulley. Slots in end supports permit lateral adjustment for pulley alignment. On type ST

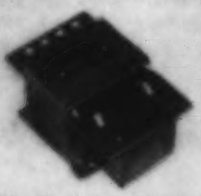
DRY-TYPE TRANSFORMERS


G1—Terminal boards

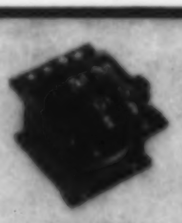
MACHINE TOOL TRANSFORMER CUSTOMER SPECIFIED ACCESSORIES GROUPS

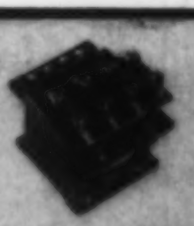
Group No.	Terminal Board		Cable Leads		Fuses			Circuit Breakers	Volt-amperes Ratings Available
	Primary	Secondary	Primary	Secondary	One	Two	Four		
G1	yes	yes	no	no	no	no	no	no	50, 75, 150, 300, 500, 750, 1000, 1500, 2000, 3000, 5000
G2	yes	yes	no	no	yes	no	no	no	50, 75, 150, 300, 500, 750, 1000, 1500, 2000, 3000, 5000
G3	yes	yes	no	no	no	no	no	yes	.. .. 300, 500, 750, 1000, 1500, 2000, 3000, 5000
G4	no	yes	yes	no	no	no	no	no	50, 75, 150, 300, 500, 750, 1000, 1500, 2000, 3000, 5000
G5	yes	yes	no	no	no	yes	no	no	50, 75, 150, 300, 500, 750, 1000, 1500, 2000, 3000, 5000
G6	yes	yes	no	no	no	no	yes	no	.. .. 300, 500, 750, 1000, 1500, 2000, 3000, 5000
G7	no	no	yes	yes	no	no	no	no	50, 75, 150, 300, 500, 750, 1000, 1500, 2000, 3000, 5000

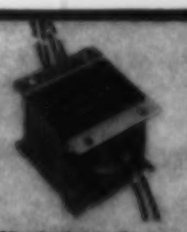

—Terminal boards, fused secondary


G3—Terminal boards, circuit breaker in secondary

G4—Secondary terminal board, primary leads out

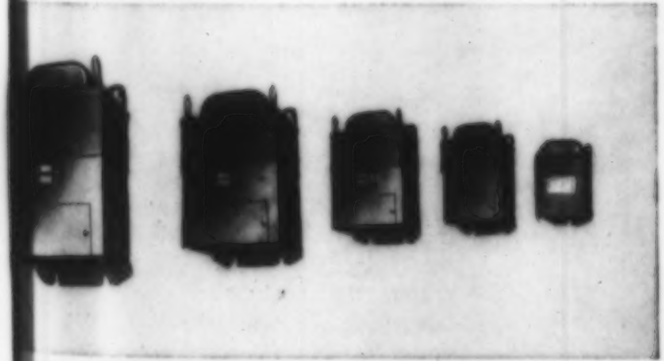

G5—Terminal boards, 2-fuse secondary board

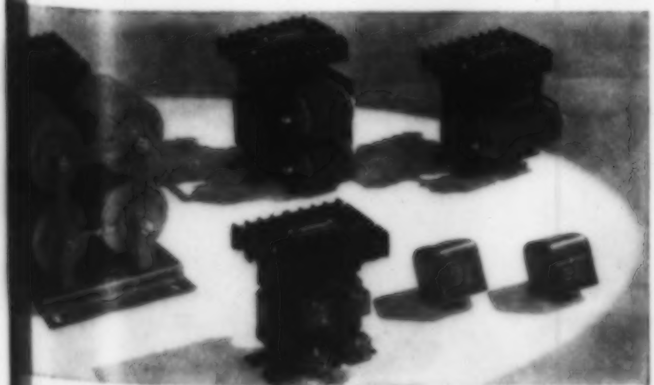

G6—Terminal boards, 4-fuse secondary board


G7—Basic transformer with leads out

UNEQUALLED FLEXIBILITY of G-E dry-types is demonstrated by the new machine tool transformer design. Merely select the rating you require and specify the accessories group your customer wants. You get a "custom-tailored" unit at a stock item price.

Here's how you can meet design requirements by specifying G-E standard dry-type transformers


COMPLETE LINE of Type M transformers covers ratings from 0.25 kva through 15 kva. These transformers are designed for rugged service in a wide variety of applications, both indoor and outdoor.


AMPLISTATS, self-saturating magnetic amplifiers combine the advantages of high gain, fast response and simple, rugged construction. Available in ratings from 1 through 930 volt-amperes.

Most of your requests for G-E dry-type transformers can be filled with a standard unit, directly from stock. For example, G-E machine tool transformers are available in 22 basic designs, yet these twenty-two basic designs offer over 100 different electrical combinations—enough to meet almost any design requirement.

The same design flexibility is apparent in the rest of G.E.'s high quality specialty and general purpose dry-type transformers, such as voltage stabilizers, control and signal transformers, and saturable reactors.

General Electric submits each Type M transformer to a minimum of 18 different tests and inspections. It is this typical high quality control of G-E products that assures you of the highest quality possible.

When you need a dry-type transformer, call on your nearest G-E Apparatus Sales Office—they will be glad to help you. Or, send in the coupon and we will promptly send you more detailed information on G-E dry-type transformers.

GENERAL ELECTRIC

General Electric Company, Section B410-11
Schenectady 5, New York

Please send me the following bulletins:

☐ GEC-1270 Transformers for Control Panels & Machine Tools
☐ GED-2024 M&D Dry-type Transformers for Industry
☐ GET-2424 Amplistats

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COMPANY ....

ADDRESS ....

CITY .... STATE ....

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TO **WASHERS**

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by FELTERS

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Wicks that pull oil in — washers that keep dirt out — are two of many jobs done by Felters Felt, to keep equipment in good operating condition.

Hard enough to be ground and chiseled, soft enough to buff a jewel — or any texture in between — each shipment of Felters Felt is uniformly controlled to exactly meet your specs.

The "Felters Design Book" contains interesting information about several grades of Felt and their uses. We will be glad to send you a copy. Write today. THE FELTERS CO., 218 South St., Boston 11, Mass.

FELTERS S.A.E. F-1 FELT is a grade suitable for oil retention where the felt is not compressed, for feeding light oil, or where unusual strength and hardness are required. Often recommended for use in resisting wear and abrasion.

This is one of many grades of Felters Felt produced for specific applications.

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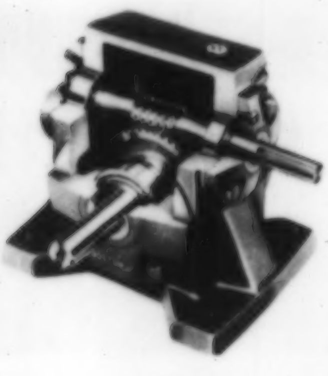
base, tension is applied through a spring, which provides tension in the form of a cushion, absorbs shock loads which would otherwise be on belts and bearings, and compensates for a large amount of belt stretch before requiring readjustment. Type SQT is for drives having fixed diameter pulleys but where center distance must be changed frequently. Made by **Automatic Motor Base Co.,** Windsor, N. J.

For more data circle MD-100, Page 211

Speed Reduction Units

Compact design and improved worm gearing are incorporated in series 100 Reductors, available in 52 standard stock models. This line of speed reducers comprises 283 different units wth ratios from 5:1 to 3600:1 and output torque ratings from 40 to 9400 lb-in. Fins on housings improve heat dissipation. Fan cooling is optional on larger sizes, except the compound units. Made by **Boston Gear Works,** 64 Hayward St., Quincy 71, Mass.

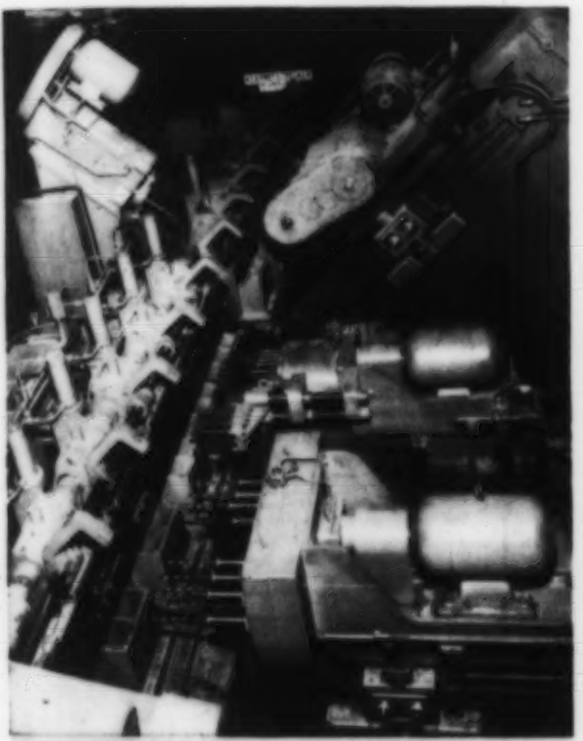


For more data circle MD-101, Page 211

Rotary Index Table

Providing accuracy for automatic work feeding, this 13-in. diameter rotary index table maintains repeat accuracies as close as 0.0005-in. Movement of the cam assures a

VICKERS® HYDRAULICS Helps Cut Costs at PACKARD . . . on Wide Variety of Jobs in New V-8 Engine Plant



Kearney & Trecker machine for drilling and counterboring bearing caps. Note Vickers Traverse and Feed Cycle Control Panels visible on two heads; advantages include smooth and constant feed rates, easy adjustability, compactness and simplified installation.

Three Greenlee Transfer Machines in automatized cylinder block line use Vickers Hydraulics. Compact Vickers Traverse and Feed Cycle Control Panel shown on head assures smooth and constant feed rate regardless of fluctuations in tool resistance or changes in hydraulic pressure or volume.

Representative of the many and varied production machines equipped with Vickers Hydraulics in the new Packard V-8 Engine Plant at Utica, Michigan are those shown here. Among the advantages of Vickers Hydraulics are: (1) simplification of design, (2) adaptable to automation, (3) ease of providing interlocks and overload protection, (4) ease of maintenance with minimum down time. Equally important, Vickers Hydraulics gives you the benefits of a nation-wide and full-time field engineering and service organization.

The Vickers Application Engineer near you will be glad to show you the benefits you can obtain by using Vickers Hydraulics. Write for a copy of Bulletin 5002.

Michigan Drill Head Co. 8 station dial machine for connecting rods and caps. Vickers Hydraulic Power Units shown are complete hydraulic "packages" (pump, electric motor, valves, oil reservoir, filter, etc.) that simplify design, and save installation and maintenance costs.

Udylite Automatic Processing Machine saves space and assures more uniform quality by using Vickers Hydraulics to raise, lower and transfer cam shafts through cleaning, coating and rinsing baths in "Lubriting" process.

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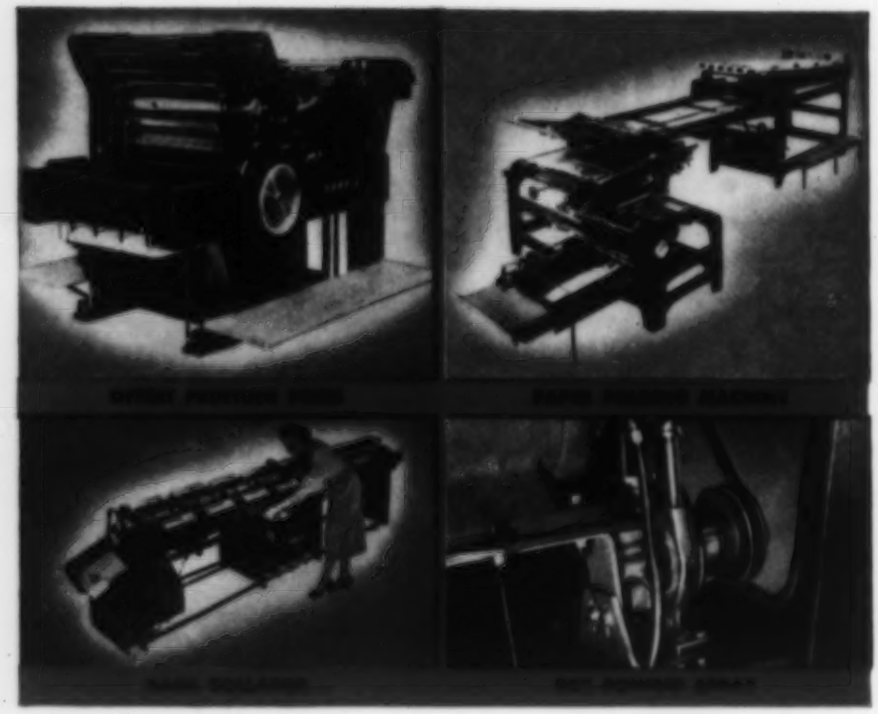
ENGINEERS AND BUILDERS OF OIL HYDRAULIC EQUIPMENT SINCE 1921



What Gast Rotary Air Pumps do on Printing Equipment may spark valuable ideas for your

AUTOMATIC MACHINES

Automation's an old story to printers! For years, they've enjoyed great labor savings from automatic equipment that feeds and positions stock, "levels" ink, applies it, dries, coats, trims, folds, collates and counts the finished product.

For years too, Gast rotary Air Pumps used on graphic arts' equipment have proved their dependability and uniform high performance—vital characteristics for *any* automatic machine which requires trouble-free components to prevent costly interruptions of interdependent operations.

On printing equipment, Gast Rotaries are used for numerous functions. Suction holds, lifts and feeds stock . . . air pressure blows stock to separate it, blows powder for drying, atomizes liquid for spraying, etc.

With a moderate vacuum of 26", you can lift 13 lbs. per square inch or *1,872 lbs. per square foot of vacuum cup area!* So think over what *important jobs Gast Air Pumps might do* on *your* automatic machines and equipment!

For details on 35 actual applications, *write for "Application Ideas" Booklet.* Gast Manufacturing Corp., P.O. Box 117-P, Benton Harbor, Michigan.

USE AIR to hold, lift, position, push, pull, rotate, suck, blow, inflate, evacuate, aerate, atomize, oxidize, etc.

Original Equipment Manufacturers for Over 25 Years

GAST ROTARY

- AIR MOTORS TO 3 H.P.
- COMPRESSORS TO 30 P.S.I.
- VACUUM PUMPS TO 28 IN.

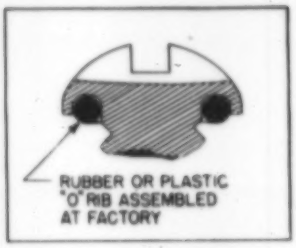
SEE OUR CATALOG IN SWEET'S PRODUCT DESIGN FILE

positively locked table top at all times. Driven by a pneumatic motor, table is available in three models: for fixed indexing of four stations, adjustable for indexing either 6 or 12 stations, and adjustable for 6, 9 or 18 stations. Made by **Bellows Co.**, 230 W. Market St., Akron 9, O.

For more data circle MD-102, Page 211

Self-Sealing Screws

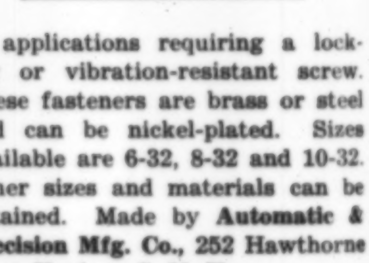
Seelscrews have integral ribs composed of silicone rubber, Neoprene or plastic, which compress under the head as the screw is tightened to form a positive hermetic seal. The plastic rib is used in applications requiring a locking or vibration-resistant screw. These fasteners are brass or steel and can be nickel-plated. Sizes available are 6-32, 8-32 and 10-32. Other sizes and materials can be obtained. Made by **Automatic & Precision Mfg. Co.**, 252 Hawthorne Ave., Yonkers 5, N. Y.



For more data circle MD-103, Page 211

Miniature Circuit Breaker

Miniature, trip-free D6761 circuit breaker is available in ratings from 5 through 35 amp. It has conventional button action, wherein the button indicates on tripping. Resetting is done manually. Disk type thermal elements with double



Bonding rubber to nylon is one of PHOENIX' specialties

We are unusually successful at bonding natural and synthetic rubber to nylon. For example, with the flexible coupling shown below, the rubber will actually rupture before bond failure.

When you work with PHOENIX you have twenty years' experience in developmental work at your disposal. Quality control is of the utmost importance at PHOENIX. Modern laboratory facilities and exacting production control methods assure the closest of tolerances.

It is PHOENIX' practice to work in strictest confidence with our customers. Whatever rubber molding problems you may have, call on us. We are here to serve you.

Please address all inquiries to Rubber Products Division.

PUTTING THIS FLEXIBLE RUBBER-NYLON COUPLING THROUGH THE PACES. TESTING ITS "BEND," TENSILE STRENGTH AND TORQUE.

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Special Motor Designs

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MOTOR DIVISION
Miehle Printing Press and Mfg. Co.
201 Bloomfield Ave., Bloomfield, N. J.

break and wiping contacts assure permanent precision calibration. Breaker has high rupture capacity and has handled over 2000-amp, 120-v, 400-cycle ac and 6000-amp, 30-v dc. It meets operational requirements of MIL-C-5809 specification. Made by **Metals & Controls Corp.**, Spencer Thermostat Div., Attleboro, Mass.

For more data circle MD-104, Page 211

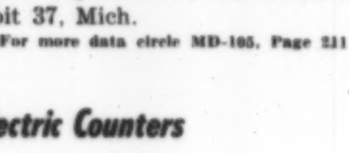
Rotary Air Valve

Hand - operated, three - position model 3010 MAC four-way rotary valve has a Hy-Car rubber rotor bonded to the shaft. Built with few working parts, it is available in 1/4 and 3/8-in. sizes. Valve is a cadmium-plated diecasting and permits variable throttling with air pressures up to 150 psi. Made by **Mechanical Air Controls Inc.**, 10030 Capital Ave., Oak Park, Detroit 37, Mich.

For more data circle MD-105, Page 211

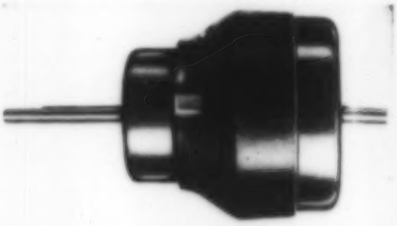
Electric Counters

Life of 50 million counts, rating of 1000 counts per minute, 7-w power consumption, balanced armatures for reliability and quiet operation are combined in PIC-600 series electric counters. Available for base or panel mounting, they have continuous duty coils and operate in any position. Six-digit models have large white figures on black number wheels. Reset to zero is by single turn of knob. Counters are available for operation on ac or dc up to 120-v. Made by **Production Instrument Co.**, 702-08 W. Jackson Blvd., Chicago 6, Ill.



For more data circle MD-106, Page 211

Shaded Pole Motor



Model SP-25 four-pole, shaded pole motor is rated at 1/60 to 1/30-hp, depending on specifications. It operates at speeds between 900 and 1550 rpm, at rated input of 115 v ac. At reduced voltages, speeds as low as 400 rpm can be attained. Motor is made for horizontal or vertical mounting in three standard frames with double or single shaft extensions up to 6 in. long. Design incorporates unit bearing construction, wherein motor housing and a single bearing are integrated in one iron casting, and a lubrication system comprised of a thermally isolated lubricant reservoir and a self-contained circulation system. Cool lubricant is pumped through the motor's bearing, then is returned to the reservoir and filtered and cooled for recirculation. Motor is totally enclosed. Made by **Electric Motors and Specialties Inc.**, King and Hamsher Sts., Garrett, Ind.

For more data circle MD-107, Page 211

Pressure Switch

Two rectangular and one round general purpose enclosures can be furnished on the style S pressure switch, designed for water systems, low-pressure air compressors, paint sprayers and similar applications requiring 1 hp or less. Switch has a capacity up to 65 psi; normal pressure settings are 20 to 40 psi. Ample wiring room, recessed terminal connectors, and positive snap action are provided. Parts are corrosion-resistant. Contacts open on pressure rise. Switch

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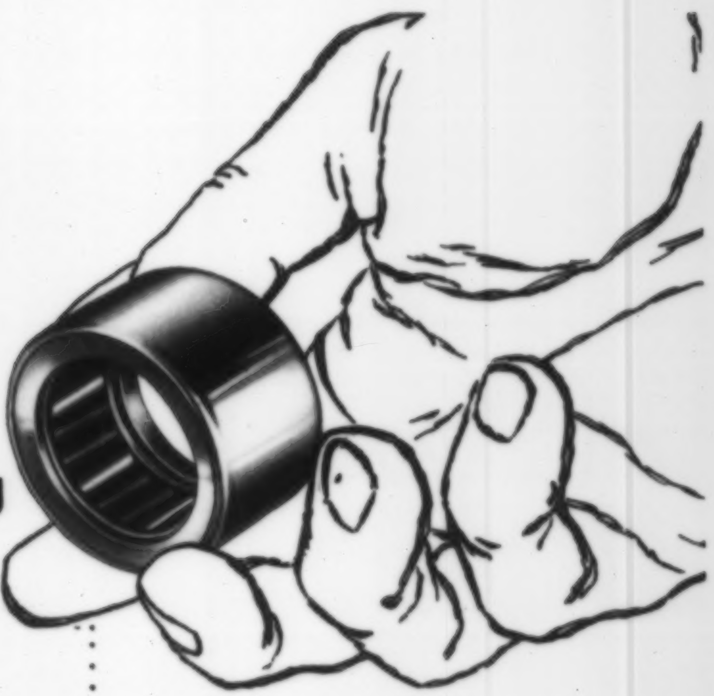
Sealed Cartridge Bearing

Versatile, low in cost, self-contained, easy to install



The Rollway Sealed Cartridge Bearing is adaptable to a remarkable variety of uses.

Low cost for a wide range of applications is offered by the various seal or retaining disc combinations: 1. A seal at each end; 2. A retaining disc at each end; 3. A seal on one end, retaining disc on the other.

Specifically tailored to each application, the Rollway Sealed Cartridge Bearing prevents dangerous overloading or wasteful underloading (see description of hardening and grinding factors for rollers, at right.) The sealed design keeps dirt *out* and lubrication *in*.

Because it is self-contained, installation is easier, faster, less costly.

FREE ENGINEERING AND METALLURGICAL SERVICE

Let's examine your bearing problems together to see how the new Rollway Cartridge Bearing can cut the costs and improve the performance of your products . . . no cost, no obligation!

RETAINING DISC is available on either or both ends.

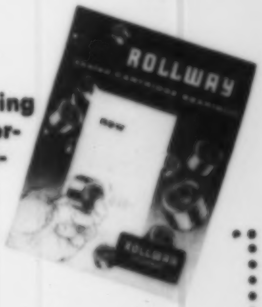
ROLLERS are available in three types: 1. Hardened but unground; 2. Hardened and ground; 3. Unhardened and unground.

SLEEVE is unhardened or heat treated, depending upon use of unhardened or hardened roller assembly.

SEALS are of sintered iron — cannot score shaft. Available on either or both ends.

FREE— Send coupon below

for Sealed Cartridge Bearing folder, with complete information, sizes, and specifications.



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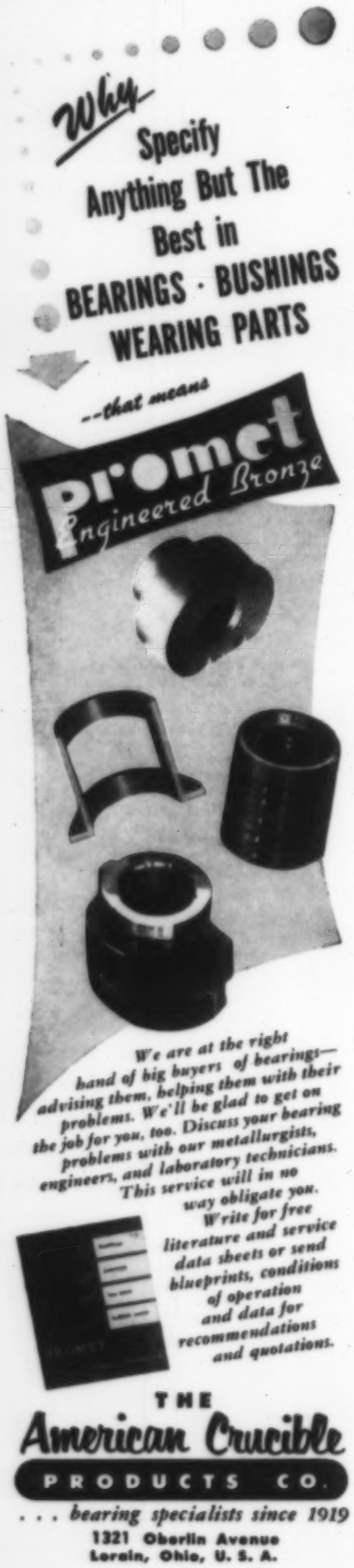

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We are at the right hand of big buyers of bearings—advising them, helping them with their problems. We'll be glad to get on the job for you, too. Discuss your bearing problems with our metallurgists, engineers, and laboratory technicians. This service will in no way obligate you. Write for free literature and service data sheets or send blueprints, conditions of operation and data for recommendations and quotations.

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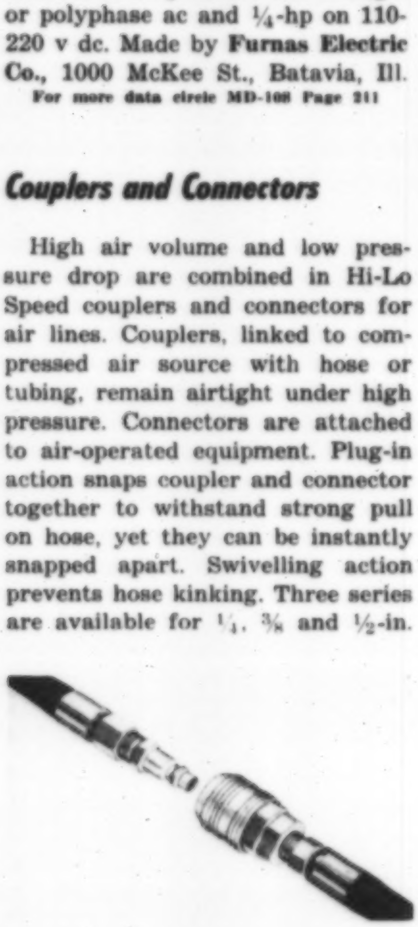
is rated at 1 hp on 110-220 v single or polyphase ac and ¼-hp on 110-220 v dc. Made by **Furnas Electric Co.**, 1000 McKee St., Batavia, Ill.

For more data circle MD-108 Page 211

Couplers and Connectors

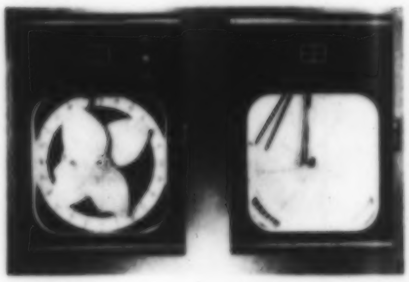
High air volume and low pressure drop are combined in Hi-Lo Speed couplers and connectors for air lines. Couplers, linked to compressed air source with hose or tubing, remain airtight under high pressure. Connectors are attached to air-operated equipment. Plug-in action snaps coupler and connector together to withstand strong pull on hose, yet they can be instantly snapped apart. Swivelling action prevents hose kinking. Three series are available for ¼, ⅜ and ½-in. hose with various thread sizes and hose inserts. All units are cadmium plated steel with stainless steel valve. The same size units will be offered in brass, stainless steel and aluminum. Made by **Aro Equipment Corp.**, Bryan, O.



For more data circle MD-109, Page 211

Time-Program, Cycle Controller

This instrument combines a two-pen, two-cam time-program controller with a cycle controller which times up to eight operations. The time-program controller can control two variables such as temperature, humidity, pressure or vacuum through any predetermined program of values by means of aluminum cams cut to the proper shapes. The two individually cut cams are locked together in any desired time relationship to each other on a single hub. In this way, temperature can be controlled through one cycle of changing values while pressure is going through another cycle independently, but synchronized with the temperature. At the same time, such operations as the opening and closing of valves, switches and dampers and the starting and stopping of motors, pumps and blowers can be automatically timed by the cycle controller. The two cases which contain these controllers can be mounted side by side or one above the other. Made by **Bristol Co.**, Waterbury 20, Conn.



For more data circle MD-110, Page 211

Frequency-Sensitive Relays

Redesigned frequency-sensitive relays are available in either crimp-cover or hermetically sealed types which weigh only 12 oz. They are not affected by vibration, shock, humidity or altitude. The frequency sensing device consists of a tuned vibrating reed driven by an electromagnet connected to the frequency reference, which can be a 400 or 60-cycle alterna-

Be Emphatic!

Specify

GM STEEL TUBING

By Rochester Products

GM STEEL TUBING BY ROCHESTER PRODUCTS, DIVISION OF GENERAL MOTORS, ROCHESTER, N.Y.

Why Aircraft Designers, too, Specify FORMSPRAG Full Complement Clutches

Aircraft designers are putting the many advantages of Formsprag Full Complement Clutches to work in a wide range of applications.

The reasons are four—all easily seen: (1) Aircraft needs the greatest torque capacity for size and weight — that's why they're used in oil drilling machinery. (2) Aircraft uses Formsprag for its precision operation without backlash—for this reason, too, press manufacturers use Formsprag. (3) Aircraft depends on the long life available with Formsprag Full Complement Clutches — automobile manufacturers are taking advantage of this feature, too. (4) Aircraft is pleased with Formsprag's low maintenance due to design simplicity—as are packaging machinery manufacturers.

It's true that aircraft clutches are specials and that Formsprag will build specials for you. But many industries are deriving these special benefits from Formsprag's *standard* clutches in over-running, backstopping, and indexing applications. Every Formsprag Clutch, whether it's a *special* or a *standard*, has only four basic parts and operates as simply as this:

Torque is delivered from one concentric race member to the other through the full complement of sprags. When torque is applied through the driving member, the sprags are instantaneously engaged between driving and driven member by an energizing spring. When torque is removed, all the sprags release instantaneously

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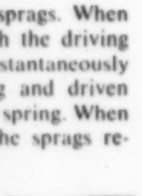
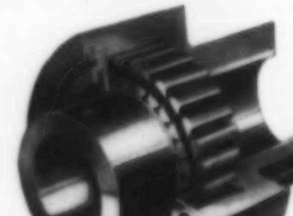
FORMSPRAG Clutches

FORMSPRAG COMPANY • 23603 Hoover Road, Van Dyke, Michigan





tor or tachometer generator. When the reference frequency resonates with the fundamental mechanical frequency of the reed, the latter vibrates and closes contacts to pull in a control relay. Standard models are furnished with single-pole, double-throw contacts to open or close a circuit as required at the preset frequency point. Resetting can be either automatic or manual. The industrial model is sealed against dust and splash; a hermetically sealed type is also available. Made by **Custom Built Controls,** 661 Delaware St., Denver 4, Colo.

For more data circle MD-111, Page 211

Counting Dial

Duodial series R turns-counting dial provides 25 and 40-turn count capacities for setting and indicating the revolutions of multiple-turn components. It is composed of two coaxial dials, the inner one counting hundredths of each turn and the outer one counting the number of completed turns. Construction prevents backlash. Dial is 2 in. in diameter, weighs 3 oz and can be used with $\frac{1}{4}$-in. shaft. Made by **Helipot Corp.,** 916 Meridian Ave., South Pasadena, Calif.

For more data circle MD-112, Page 211

Hydraulic Cylinders

Line of hydraulic cylinders for agricultural and industrial uses is made of roller burnished seamless mechanical tubing with aluminum pistons and heads. Bores from $1\frac{1}{2}$ to 5 in. and strokes up to 10 ft are available in agricultural cylinders

REVOLUTIONARY IDEA?

YES . . . NOW HOUGHTON'S NEW PACKING DESIGN IS

PROVED BY PERFORMANCE

NOW you get many advantages over round-shoulder packings with long-lip bevel like this

PREFORMED SHOULDER, sidewall flare and preloading features of NEW No. 1243-3 PACKINGS are shown in cross-section diagram

Here's what years of testing and actual performance records have established about the benefits of *Vim No. 1243-3 preformed, preloaded Packings:*

- 1. Leaks at low pressure are eliminated!
- 2. Packings won't rupture at top pressures!
- 3. Friction is substantially reduced!

The widening use of these unique cup packings has also served to upset the general belief that synthetic rubber could not be thoroughly impregnated in leather. Houghton engineers have demonstrated in No. 1243-3 that *the advantages of both can be combined for greater effectiveness!*

Ask the Houghton Man for more detailed information. Or write to Packing Research Department, E. F. Houghton & Co., 303 West Lehigh Avenue, Philadelphia 33, Pa.

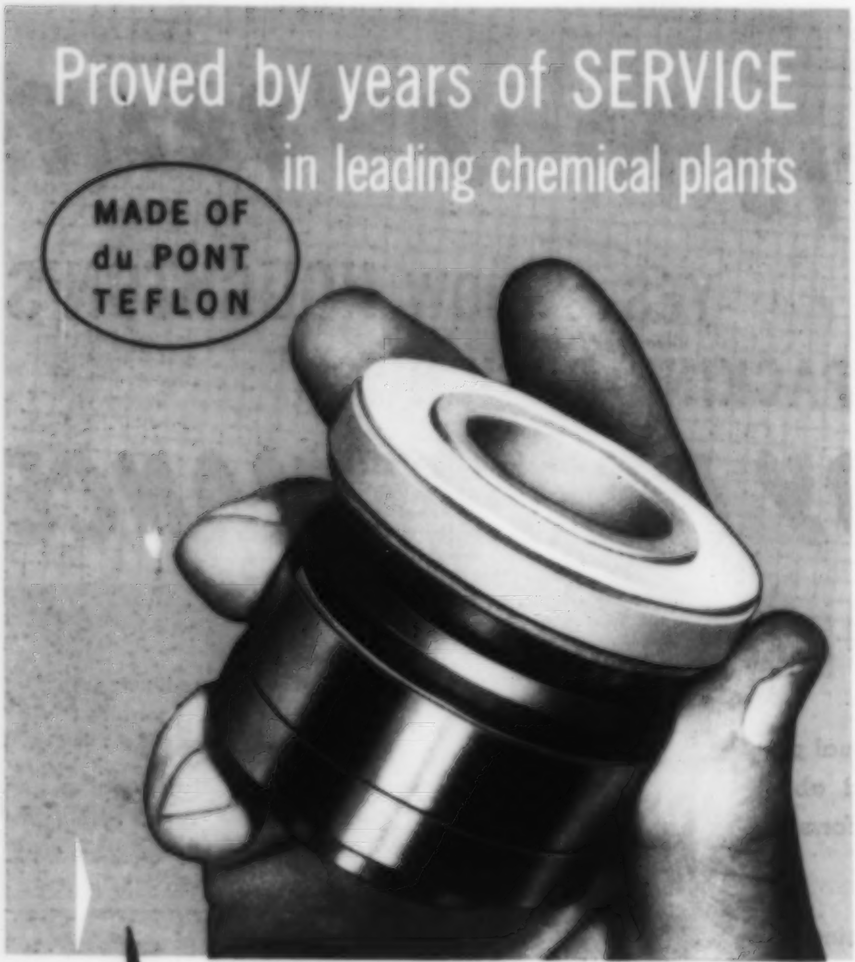
VIM NO. 1243-3 RUBBER IMPREGNATED LEATHER CUP PACKINGS

. . . a product of

E. F. HOUGHTON & CO.

PHILADELPHIA · CHICAGO · DETROIT · SAN FRANCISCO

Ready to give you on-the-job service . . .



CHEMISEAL SHAFT SEALS

Customers report unsurpassed performance and much longer life under a wide variety of chemical service conditions, with Chemiseal Mechanical Seals.

A superior material—duPont TEFLON, and a one-piece balanced bellows design are responsible.

Chemiseals rotate with shaft. Only bearing surface is between precision ground stationary and rotating faces—the latter being an integral part of the TEFLON bellows unit.

Advantages include: Applicable to all chemical requirements, including clear, abrasive and tarry materials. Seal drop-tight and stay tight. Low friction load on shaft. No scoring of shafts—shafts already scored can be satisfactorily sealed. Pressures at the seal to 100 psi at 75° C or 75 psi at 100° C. Standard sizes ⅝" to 2⅛". Other sizes on special order. Over-all length 2½".

Write for Bulletin No. MS-954.

UNITED STATES GASKET CO., Camden 1, N. J.

UGS

FABRICATORS OF FLUOROCARBONS AND OTHER PLASTICS

Representatives in principal cities throughout the world

with 1500-psi working pressure and industrial cylinders with 2500-psi working pressure. Cylinders are convertible, providing single or double action or stroke control in one unit. Various end fixtures, packings and accessories are available. Made by **Hemco Mfg. Inc.**, Argonia, Kans.

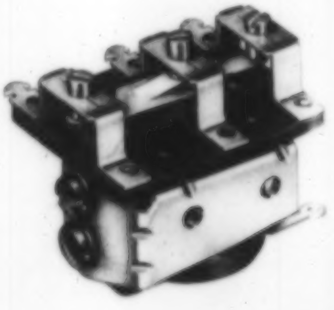
For more data circle MD-113, Page 211

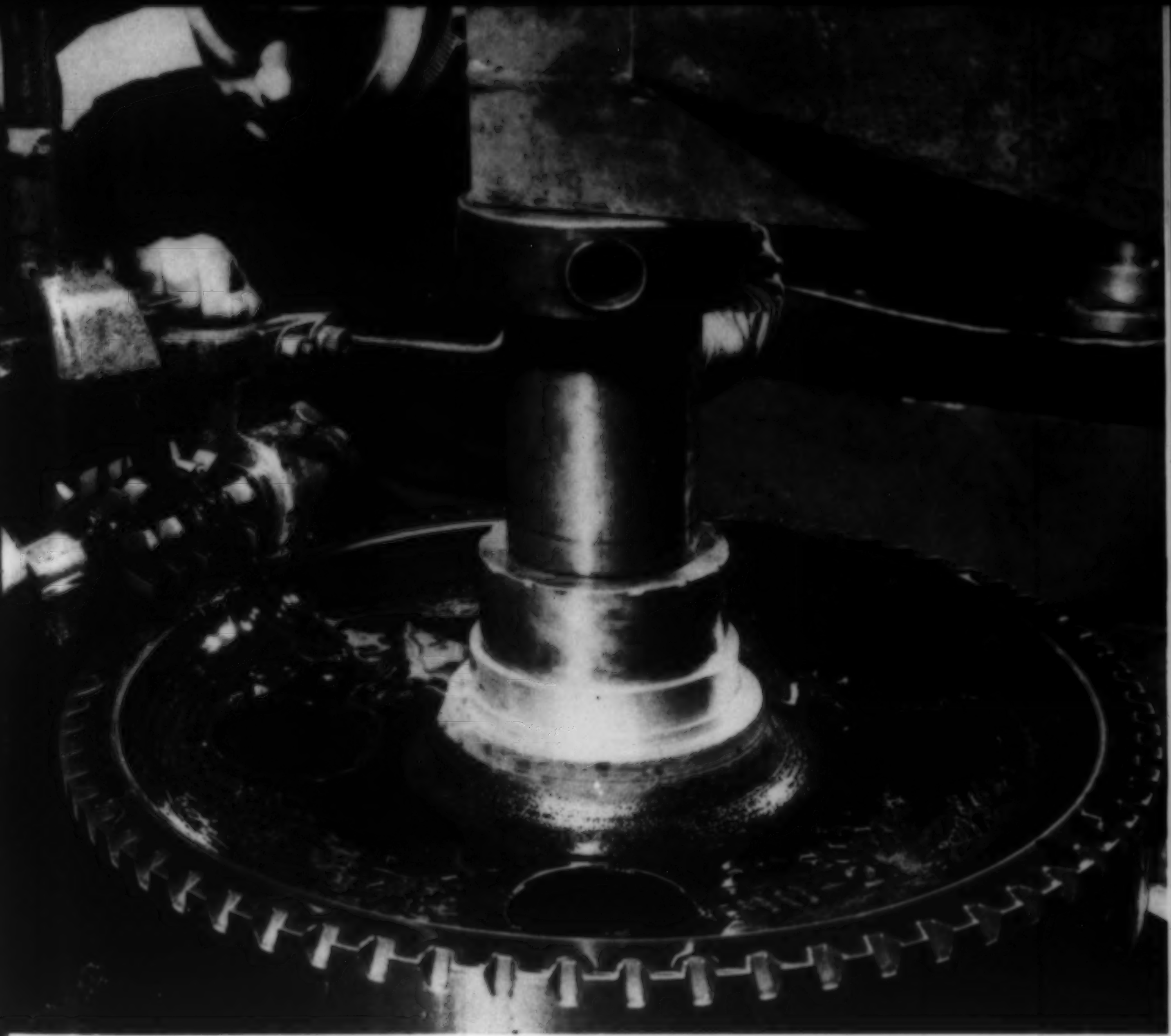
Silver Bearing Liner

Porous silver bearing liner, made from sintered wire, carries bearing loads as high as 50 to 75 per cent of those of solid silver. Void content can be in the range of 10 to 50 per cent. Liner can be impregnated with various lubricants. Material is supplied as completed bearings fitted into a steel housing or in the form of flat sheet, to be formed into half or full bearing liners. Made by **Micro Metallic Corp.**, 30 Sea Cliff Ave., Glen Cove, N. Y.

Miniature Relay

Factory-set to operate on 10 milliwatts, the SO type miniature relay can be adjusted down to 2 milliwatts, or to any desired pick-up or drop-out by means of fine screw contacts. It requires a space 1⅛ x $1\frac{7}{32}$ x 1¼ in., weighs 1½ oz and has a single-pole, double-throw contact arrangement. Life expectancy is 250,000 operations at a





Pittsburgh Gear switched to SSW forged blanks... saved 50 minutes machining time, extended cutter life 20%

Switching to SSW forged steel gear blanks in manufacturing mine locomotive drive gears has given Pittsburgh Gear Company, Neville Island, Pa. . . .

- **savings of 50 minutes in machining time.**
- **better performance through extended service life (cutter life increased 20%).**
- **reduced cutter costs.**
- **over-all lower initial cost.**

These benefits are a result of the more uniform internal structure and close dimensional tolerances of Standard Steel blanks. Machining is done on a single setup, at a maximum speed because there's no danger of hard spots and sand porosity as with castings.

Pittsburgh Gear knows their product must take extra-rugged wear in mining operation. In service the continuous starting and stopping of mine locomotives subjects drive gears to severe shock and impact. The denser core and uniform structure of these SSW blanks contribute to longer-lasting, failure-proof life of these gears.

Like Pittsburgh Gear, you can improve your product and cut your costs with SSW forgings. Write today for the new Standard Steel folder on forged weldless rings and flanges. Use the coupon now.

Standard Steel Works Division

BALDWIN-LIMA-HAMILTON

Dept. 8564, Standard Steel Works Division
Baldwin-Lima-Hamilton Corporation, Burnham, Pa.

Please send me new Standard Steel Works folder containing detailed information on Forged Weldless Rings & Flanges.

Name ______ Title ______
Company ______
Address ______
City ______ Zone ______ State ______

View of Emsco Swivel Joints on one loading station.

Emsco 8" type LP Swivel Joint Style 2 with flanged ends for loading dock service.

EMSCO SWIVEL JOINTS SELECTED FOR NEW LOADING WHARF

We are proud to have supplied the Swivel Joints installed on this loading wharf making it one of America's newest and most modern loading facilities. Here are installed a score of Emsco 6" and 8" type LP Swivel Joints. Free turning and easy maintenance were prime factors in the selection of Emsco for this job. In the cross section note how the thrust load is absorbed through the ball bearings – how easily bearings can be adjusted. Note also how readily the packing can be replaced simply by separating the joint as one would a union. No return of joint to the factory for service. Emsco assures you a new kind of dependability in Swivel Joints.

Emsco's complete line includes Swivel Joints for high or low pressure, high vacuum, corrosive or high temperature service; for gas, liquid or semi-solids. Check with us or our field representatives. Over 500 various combinations to choose from. Sizes ⅜" to 12". Pressures to 15,000 lbs. Temperatures to 750° F.

Simplicity of Emsco's patented design assures a new kind of performance and dependability in Swivel Joint construction.

EMSCO

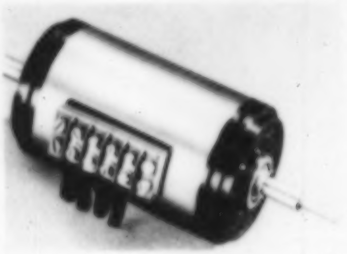
EMSCO MANUFACTURING COMPANY
Box 2098, TERMINAL ANNEX
LOS ANGELES 54, CALIF.
Houston, Texas
Garland, Texas

contact rating of 1.5 amp at 28 v dc. Vibration resistance is 20 g at 10 to 55 cycles, or 5 g at 10 to 500 cycles. Standard coil resistances available are 4000, 6500 and 10,000 ohms. Temperature range is −55 to 85 C. Units are available in open types, dust-tight and hermetically sealed enclosures. Made by **Advance Electric & Relay Co.**, 2435 N. Naomi St., Burbank, Calif.

For more data circle MD-115, Page 211

Magnetic Clutch

Precision electromechanical magnetic clutch, model T508, is designed for servo system applications requiring engagement or disengagement of either one or both shafts from a single input shaft.

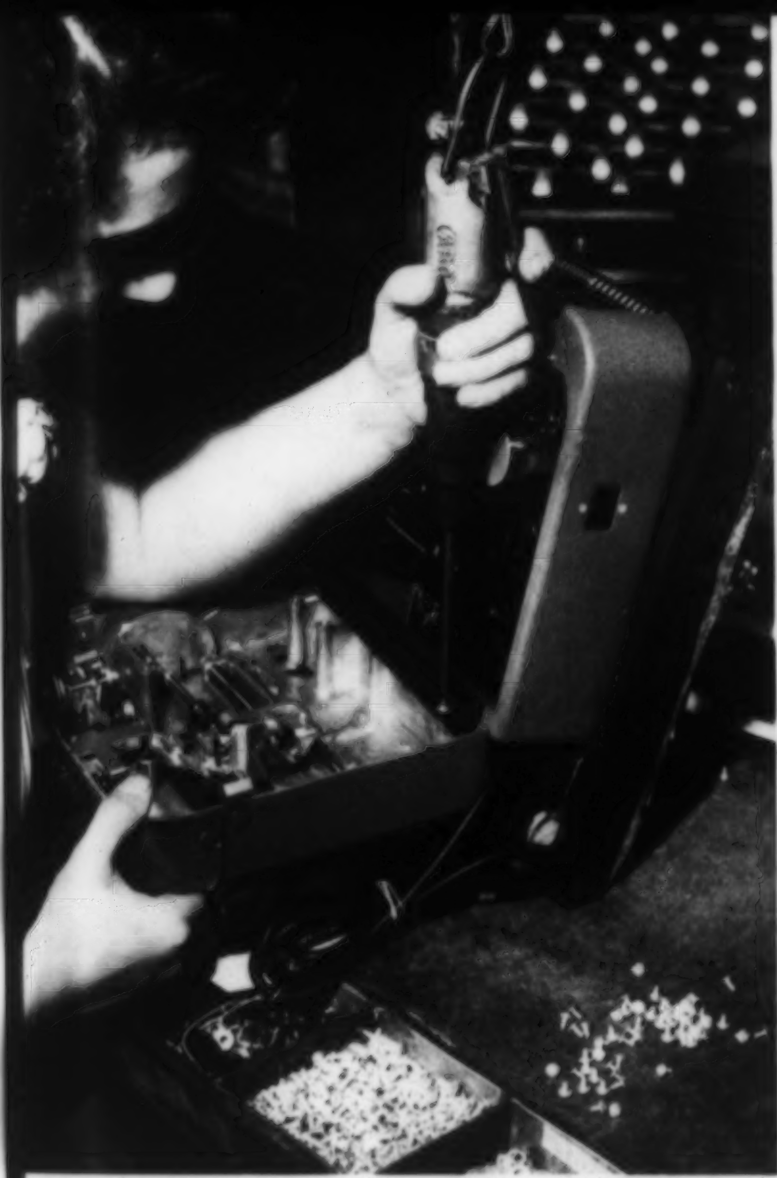


Two magnetic coils and two sets of couplings are enclosed in one housing. Functions of the shafts can be reversed so that outputs can be used as inputs, permitting the selection of either of two input rotations to be transmitted to a single output shaft. Made by **Sterling Precision Instrument Corp.**, Instrument Div., 34-17 Lawrence St., Flushing 54, N. Y.

For more data circle MD-116, Page 211

Integral Air Pump and Motor

Model K-3 integral air pump and motor unit provides 28 in. Hg continuous vacuum, 20 psi pressure and 7.2 cfm air displacement. Unit has a ball bearing motor and rotary pump, with a cast iron housing and two steel blades with automatic adjuster to assure constant blade-to-wall contact. Motor has automatic thermal overload protection, ball bearing greasing system and an automatic lubricator which operates 60 to 80 hours be-



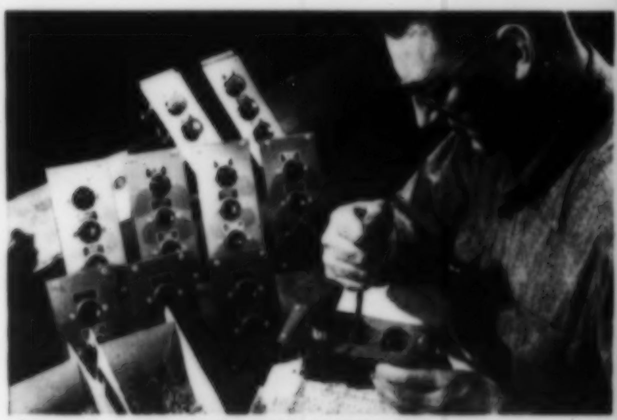
RUGGED PERFORMANCE STANDARDS are met by use of 39 Phillips Screws on one electronic assembly at the Gray Manufacturing Company, Hartford, Conn., makers of Audograph Soundwriter. Gray's Chief Estimating Engineer says, "Improved efficiency and speed of production make the selection of Phillips Screws almost automatic. We get up to 20% increased production."

STRONGER CONSTRUCTION

SWIFTER PRODUCTION

NEATER INSTALLATION

with Phillips Cross-Recessed-Head Screws



SURFACE MARRING DANGER ELIMINATED on certain types of push button stations manufactured by The Clark Controller Company, Cleveland, Ohio, a major manufacturer of one-of-a-kind electrical controls. "We selected Phillips Screws because of their neat appearance and because they permit easy assembly with driver slippage reduced to a minimum," says Engineering Standards Manager.

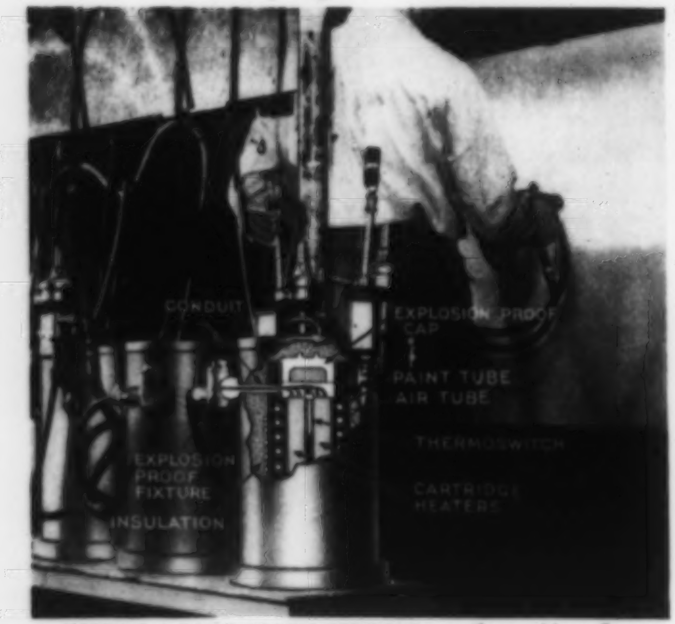
TIME AND LABOR SAVING ADVANTAGE . . . in addition to extra-secure bonding . . . makes SEMS type Phillips Screws, with attached lock washers, very popular in Otis Elevator Company's production of these current-carrying contacts. Says Otis' Consulting Engineer, "Phillips Screws mean greatly increased production, decreased assembly time, a neater installation, tighter, more positive contact, and surer driver bit centering."

MANUFACTURERS OF • PHILLIPS SCREWS • CROSS-RECESSED-HEAD

THE FASTENERS OF TODAY...
AND OF THE FUTURE
✖ *marks the spot*
the mark of extra quality

Allmetal Screw Products Company, Inc. • American Screw Company • Atlantic Screw Works, Inc. • The Blake & Johnson Co. • Central Screw Company • Continental Screw Company • The Eagle Lock Company • Elco Tool and Screw Corporation • Great Lakes Screw Corporation • The H. M. Harper Co. • The Lamson & Sessions Company National Lock Company • The National Screw & Manufacturing Co. • Parker-Kalon Div. General American Transportation Corporation • Pheoll Manufacturing Company Rockford Screw Products Company • Scovill Manufacturing Company • Shakeproof Division Illinois Tool Works • The Southington Hardware Manufacturing Company Sterling Bolt Company • Universal Screw Company • Wales-Beech Corporation

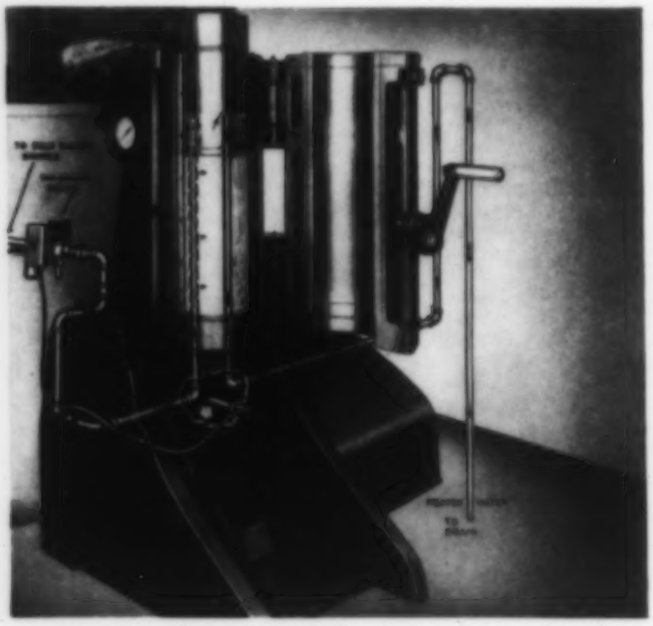
How would you solve these tricky temperature control problems?


CONDUIT
EXPLOSION PROOF CAP
PAINT TUBE
AIR TUBE
THERMOSWITCH
CARTRIDGE HEATERS
EXPLOSION PROOF FIXTURE
INSULATION

1. KEEPING A PAINT HEATER EFFICIENT was the problem. It was solved with the help of a Fenwal heavy duty block THERMOSWITCH® unit. Heat from a 2000-watt source is accurately held at 150F — for top efficiency. Users just plug it in, forget it. THERMOSWITCH unit is attached to explosion-proof block, as shown in diagram.

PITCH
THERMOSWITCH
HEATERS

2. PROTECTING MACHINERY. Engineers wanted to prevent motor damage to automatic brush assembly equipment by starting the operation shortly *before* the sealing compound (pitch) reached the liquid stage. Upon Fenwal advice an inverse type THERMOSWITCH unit was installed to close circuit when pitch temperature reaches 180F. Circuit opens *only should* pitch heaters fail.



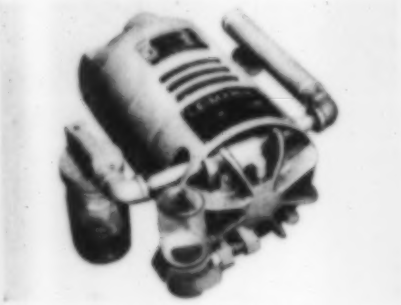
3. COOLING PRINTING PLATES. If printing plates cool too fast, they shrink — if too slow, they become porous. Reject plates were practically eliminated when a solenoid water valve was substituted for a hand valve — with a Fenwal THERMOSWITCH unit guarding the water temperature closely and operating the valve whenever the set point was passed. THERMOSWITCH shell itself "senses" change.

Fenwal
catalog no. 400
THERMOSWITCH Thermal Controls
Sensitive ... but only to heat
FENWAL INCORPORATED

4. FREE CATALOG brings you complete data on the unique THERMOSWITCH unit. More details on problems discussed here if you want them. Fenwal engineers are always glad to help on special temperature control problems involving heat, humidity, pressure and other variables. Write **Fenwal Incorporated, 197 Pleasant St., Ashland, Mass.**

Fenwal THERMOSWITCH®

Controls Temperature — Precisely

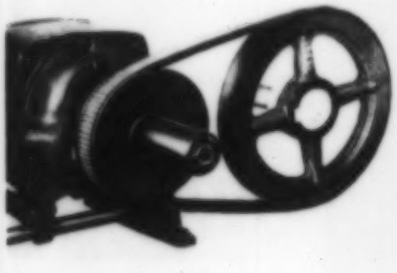


fore refilling is necessary. Overall size is 18½ x 15 x 7 in. high. Made by **Leiman Bros. Inc.**, 102 Christie St., Newark 5, N. J.

For more data circle MD-117, Page 211

Variable-Speed Pulley

Changes in operating speed are effected quickly and easily by this variable-speed pulley, which provides ratios up to 3:1 at 7½ to 15 hp. Pulley accommodates a 2¾-in. top width variable-speed



belt. Standard bores are 1¼, 1⅜ and 1⅝ in. Minimum pitch diameter is 4.35 in.; maximum pitch diameter is 13.1 in. Length of bore is 3¾ in.; maximum bore is 1⅝ in. Made by **Lovejoy Flexible Coupling Co.**, 4818 W. Lake St., Chicago 44, Ill.

For more data circle MD-118, Page 211

Centrifugal Switches

High-speed, nonfluttering Syncro-Snap centrifugal switches provide instantaneous cut-in or cutout. Snap-type switching action is completed within 3 revolutions of the shaft to which the switch is attached. Switches are temperature compensated to provide precise operation at a predetermined speed over a wide temperature range. They can be used as overspeed or

(*Continued on Page* 260)

hob list
(Revised April 1955)
CUTTERS · BROACHES · SPECIAL TOOLS
BRAD FOOTE GEAR WORKS, INC.

NEW
Revised Edition
56-page Catalog of tools
for making:

WORMS WORM GEARS HERRINGBONE SPUR STRAIGHT BEVEL ZEROL INTERNAL SPIRAL BEVEL RACKS ACME SCREWS SPROCKETS SPLINES KEYWAYS

This FREE Book will cut your gear costs!

When we first offered the BRAD FOOTE Hob List about a year ago the response was tremendous. Thousands of gear designers and engineers recognized in this catalog an opportunity to substantially cut their gear costs. And now, a new revised issue makes possible even greater savings.

The reasons are obvious. Since 1923, BRAD FOOTE has specialized in custom-built as well as production gears. Over the years we have built up a tremendous stock of hobs, cutters and broaches, used in thousands of gear cutting jobs—a stock that enables us to do just about any gear cutting job you may have.

By laying out gears so that they can be made from tools now in the BRAD FOOTE stock, you can save substantially on tooling costs . . . and eliminate delays necessary for the preparation of tools.

The Revised BRAD FOOTE Hob List includes all tools prepared through April, 1955. If you have a copy of the Hob List, write for the revised edition. And if you haven't had a Hob List, write for your free copy—find out how it can save you time and money on gears.

IMPORTANT NOTE:
If you now make your own gears, ask for a copy anyway. You may find that it is cheaper for us to make them.

BRAD FOOTE GEAR WORKS, INC.
1311 South Cicero Ave., Cicero 50, Ill.
Please send me my free copy of the new revised Hob List.
NAME
TITLE COMPANY
ADDRESS

BRAD FOOTE GEAR WORKS, INC.
1311 South Cicero Avenue • Cicero 50, Illinois
Bishop 2-1070 • OLympic 2-7700 • TWX: CIC-2856-U

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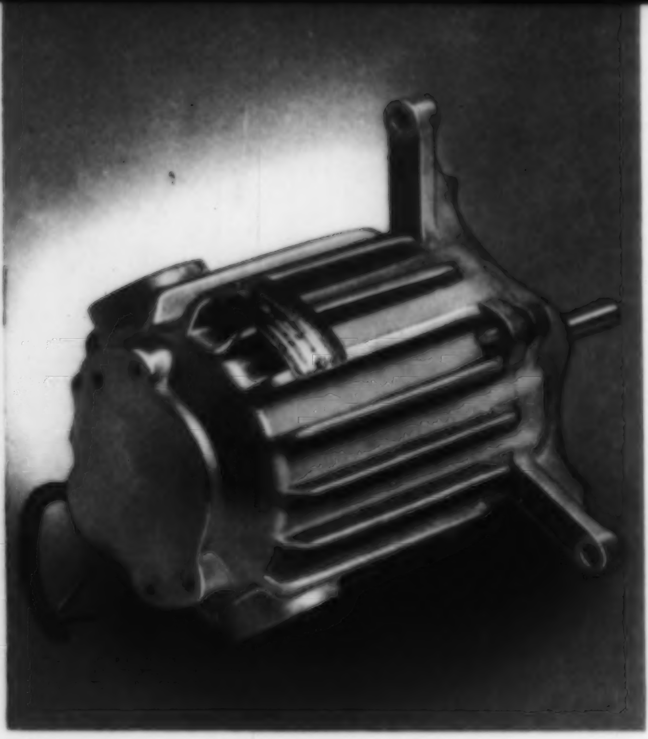
AMERICAN GEAR & MFG. CO.
Phone: Lemont 920
Lemont, Illinois

PITTSBURGH GEAR COMPANY
Phone: SPaulding 1-4600
Pittsburgh 25, Pennsylvania



1. UNIVERSAL MOTOR FOR BLOWER MEETS LIMITED SPACE REQUIREMENTS

General Electric engineers were asked to supply a specially mounted motor for an axial fan. Among the special considerations were a limited amount of space for the motor and need for exceptionally long brush life.

The space problem was solved by G-E engineers with a universal motor designed with a special tripod mounting, extended bearing nose, and a diameter of only $6\frac{1}{16}$ inches. Extensive testing proved this motor to have more than required brush life. This General Electric air-over motor can also be supplied in Class 1, Group D, explosion-proof construction.

2. SPECIAL DC BRAKE MOTOR DESIGNED FOR LOCOMOTIVE DOOR OPENER

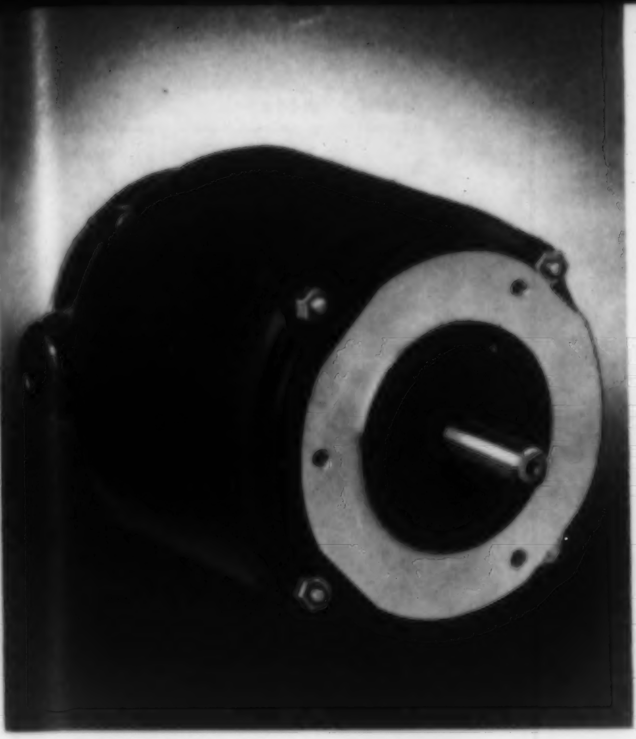
Limited space requirements presented a problem to G-E engineers when they were asked to design and build a motor to open and close a 1200-pound locomotive car door. Another specification: positive starting and stopping action.

A team of General Electric motor experts designed a special space-conserving, side-wall mounted motor to be used with a gear reducer and magnetic brake.

G.E. offers a complete line of d-c motors in the following enclosures: drip-proof, totally enclosed non-ventilated, explosion-proof, severe-duty, navy- and marine-type construction.

These four cases show how you

THIS TEAM OF G-E MOTOR EXPERTS is ready to tackle your special drive problems: (1) Lubrication specialist (2) Mechanical design engineer (3) Vibration specialist (4) Electrical engineer (5) Product design engineer (6) Heat transfer specialist.



3. SYNCHRONOUS INDUCTOR MOTOR IDEAL FOR LOW-SPEED CAMERA DRIVE

This General Electric customer required a special low-speed motor for an automatic camera drive. Among the customer's specifications was precise starting and stopping action.

Experience indicated that a synchronous inductor motor would be ideal for this low-speed application. The synchronous inductor motor G-E engineers came up with had a rabbet fit for direct mounting to the camera. The motor operates at 75 rpm and a torque of 75 oz-in., and is giving excellent service.

Synchronous inductor motors—a G-E exclusive—are available in 115- and 230-volt ratings 60, 50, and 25 cycles.

4. SHADED-POLE INDUCTION MOTOR TAILORED TO VIBRATING SANDER

An industrial sander manufacturer requested a built-in motor to withstand severe vibrations.

G-E engineers, working closely with customer engineers, helped to develop a hand sander, cool to the touch, by adapting a specially designed shaded-pole motor rotor and stator.

Not only were these shaded-pole motor parts designed to withstand vibrations encountered in application, they also allowed the customer to greatly simplify assembly operations.

G-E shaded-pole motor parts are available in ratings from 15 mhp to 1 12 hp, 115 and 230 volts, 60 and 50 cycle.

solve drive problems when you buy General Electric specialty motors

You buy solutions to your electric drive problems when you buy versatile General Electric specialty motors. These motors, applied by experienced G-E application engineers, can really solve the "tough ones" for you—design problems like those posed above.

Among the specialty motor products available for your application are: d-c motors and generators, shaded-pole motors, specialty induction motors, amplidynes, tachometer generators, low-speed synchronous inductor motors, dynamotors, and universal motors and parts.

TURN OVER YOUR SPECIAL MOTOR PROBLEMS to General Electric early in your planning by contacting your local G-E Apparatus Sales Office. Or, if you prefer write describing your requirements including quantity and application to Section 704-54, General Electric Company, Schenectady 5, N. Y.

Progress Is Our Most Important Product

GENERAL ELECTRIC

Announcing a
BIG IMPROVEMENT
IN SMALL MOTOR BRUSHES

Exhaustive tests indicate that Stackpole Grade 373 fractional horsepower motor brushes represent a major development in their field.

On vacuum cleaners, food mixers, sewing machines, calculators, and similar equipment, these new brushes have shown *materially* longer life, usually with better performance than any previous grades. Commutator wear is held to a minimum.

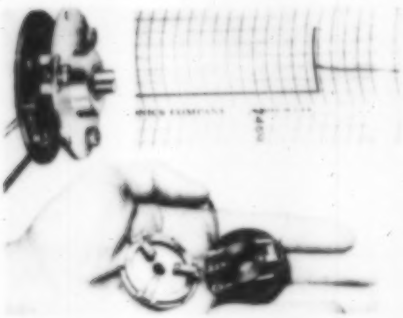
As always in applying brushes to any given motorized equipment, however, the one best way is to test them fully on that actual equipment and as close to possible under its typical operating conditions. Stackpole welcomes the opportunity to make or to facilitate such a test for you.

Solely on this basis of positive performance proof, it now becomes pretty clear that Grade 373 brushes will set new life and performance standards for small motors in a wide diversity of uses.

STACKPOLE CARBON COMPANY,
St. Mary's, Pa.

STACKPOLE
Grade 373
FAR LONGER BRUSH LIFE - *Plus*
EQUAL (OR BETTER) PERFORMANCE THAN PREVIOUS GRADES

(*Continued from Page 257*)

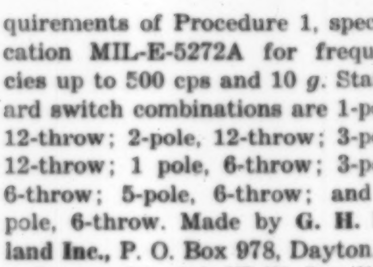


underspeed limit controls, or can be used in pairs to limit high as well as low speeds for a single application. Switches are available for any speed to 13,000 rpm. Switch life is in excess of 1 million cycles. Made by **Torq Engineered Products Inc.**, 34 Interstate St., Bedford, O.

For more data circle MD-119, Page 211

Solenoid-Powered Relay

Compact model BD 4 E relay has an indexing lock which prevents misalignment of contacts and enables the relay to withstand a wide range of rotary solenoid power. Unit meets military vibration requirements of Procedure 1, specification MIL-E-5272A for frequencies up to 500 cps and 10 *g*. Standard switch combinations are 1-pole, 12-throw; 2-pole, 12-throw; 3-pole, 12-throw; 1 pole, 6-throw; 3-pole, 6-throw; 5-pole, 6-throw; and 7-pole, 6-throw. Made by **G. H. Leland Inc.**, P. O. Box 978, Dayton, O.



For more data circle MD-120, Page 211

Small Air Motor

Vane type 71J-40 air motor develops 1 hp at 90 psi pressure. It is available in five styles with center spindle gear case and in three styles with off-center spindle gear

YES SIR!

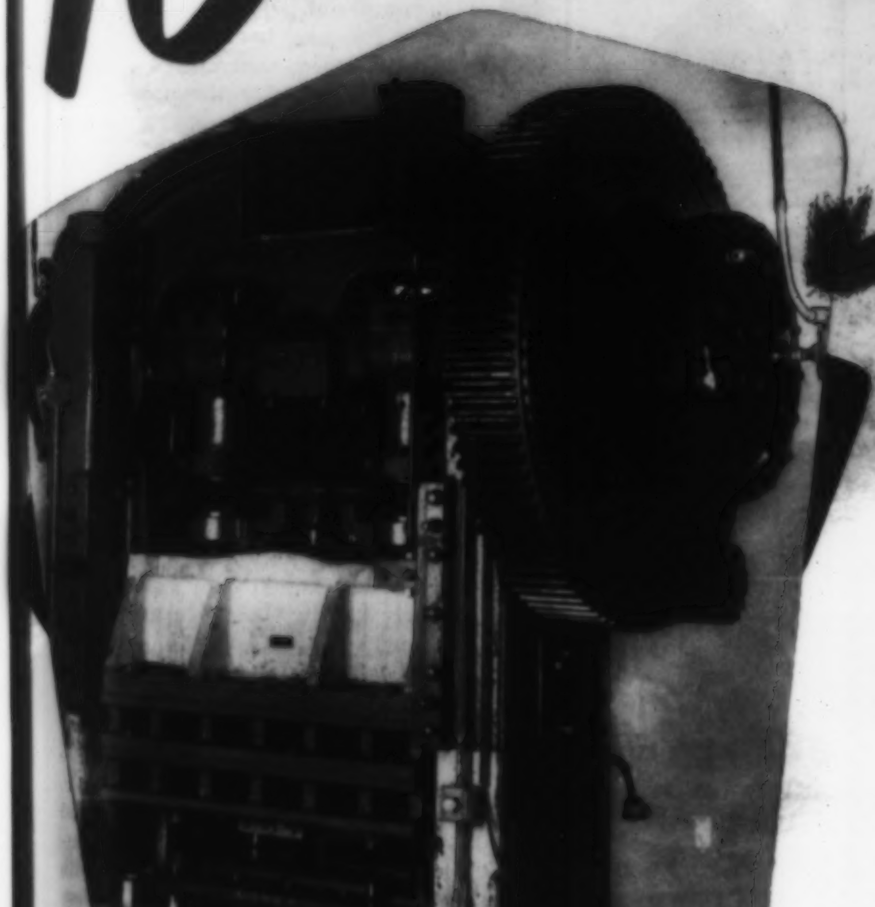
16% PRODUCTION INCREASE

at

Progress Manufacturing Company

of Philadelphia, Pa.

with WICHITA LOW INERTIA *Air-Tube* CLUTCHES & BRAKES



What a difference! Now, that Progress Manufacturing Company, a leading manufacturer of outdoor lanterns and lighting fixtures, has converted this Bliss 7A Press to a Wichita Clutch and Brake operation.

Ultimate outcome — increased profit for the company, higher rate of pay for employees — and the conversion of a LIABILITY to an ASSET without a major investment . . . plus a safer operating press, more easily controlled, and one which turns out better parts.

Further Proof that PROGRESS is PROGRESSIVE

Modernize by converting your presses and other equipment to Wichita Clutches and Brakes!

For Complete Information

CONSULT YOUR NEAREST WICHITA ENGINEER

WICHITA DISTRIBUTORS

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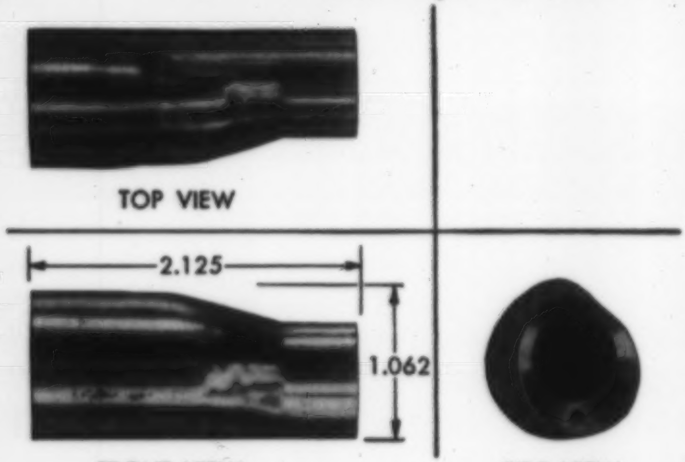
Smith-Keser & Co., New York, N. Y.
Frank W. Yorline Co., Chicago, Ill.
Power Rig & Equipment Co., Inc., Long Beach, Calif.
Robert R. King Co., Cleveland, Ohio
John C. Burge, Oklahoma City, Oklahoma
Dominion Power Press & Equipment Ltd., Toronto, Canada
Oil Field Motor Service, Alice, Texas
Hunt Tool Co., Houston, Texas
Industrial Air Controls Co., Ft. Worth, Texas

WICHITA *Clutch*
COMPANY, INC.
WICHITA FALLS, TEXAS, U. S. A.

This 3 Dimensional Cam Incorporates Over 1,000 Precision Dimensions!



PARKER CAMS MAKE POSSIBLE THE PERFORMANCE AND CONTROL OF SUPERHUMAN MECHANICAL FUNCTIONS

There are engineers with three dimensional cam problems who are unaware that their difficulties can be overcome—that Parker can design a single cam with an infinite number of exact stations—then reproduce thousands of absolutely identical duplicates to control relative motions through geometric and non-geometric curves in three dimensions.

Impossible performances are now daily routine through cam control in

SUPERSONIC AIRCRAFT • INSTRUMENTATION
AUTOMATION • ELECTRO-MECHANICAL ENGINEERING

Send today for your copy of the astonishing story of a Parker-engineered cam that is the "brain center" for jet aircraft. Contact Parker for full information on how Parker cams can "think" for your machinery.

THE
PARKER
by Parker
STAMP WORKS, INC.
CAM DIVISION
FRANKLIN AVENUE • HARTFORD, CONNECTICUT

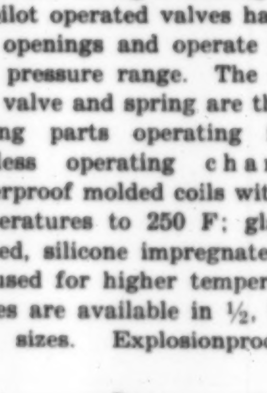
New Parts

case. The former type is less than 13 in. long and $3\frac{1}{4}$ in. in diameter; the latter is less than 15 in. long and $4\frac{1}{2}$ in. in diameter. Designed for continuous duty, the motor can provide quick starts and quick stops without overheating and can stall repeatedly without burning out. Nonsparking, it is safe for use in hazardous locations. Speed, controlled by an air valve, is variable throughout the motor's entire range. Maximum operating speeds of motors range from 120 to 1200 rpm; maximum torque is from 20 to 190 lb-ft. Made by **Gardner-Denver Co.,** Keller Tool Div., Grand Haven, Mich.

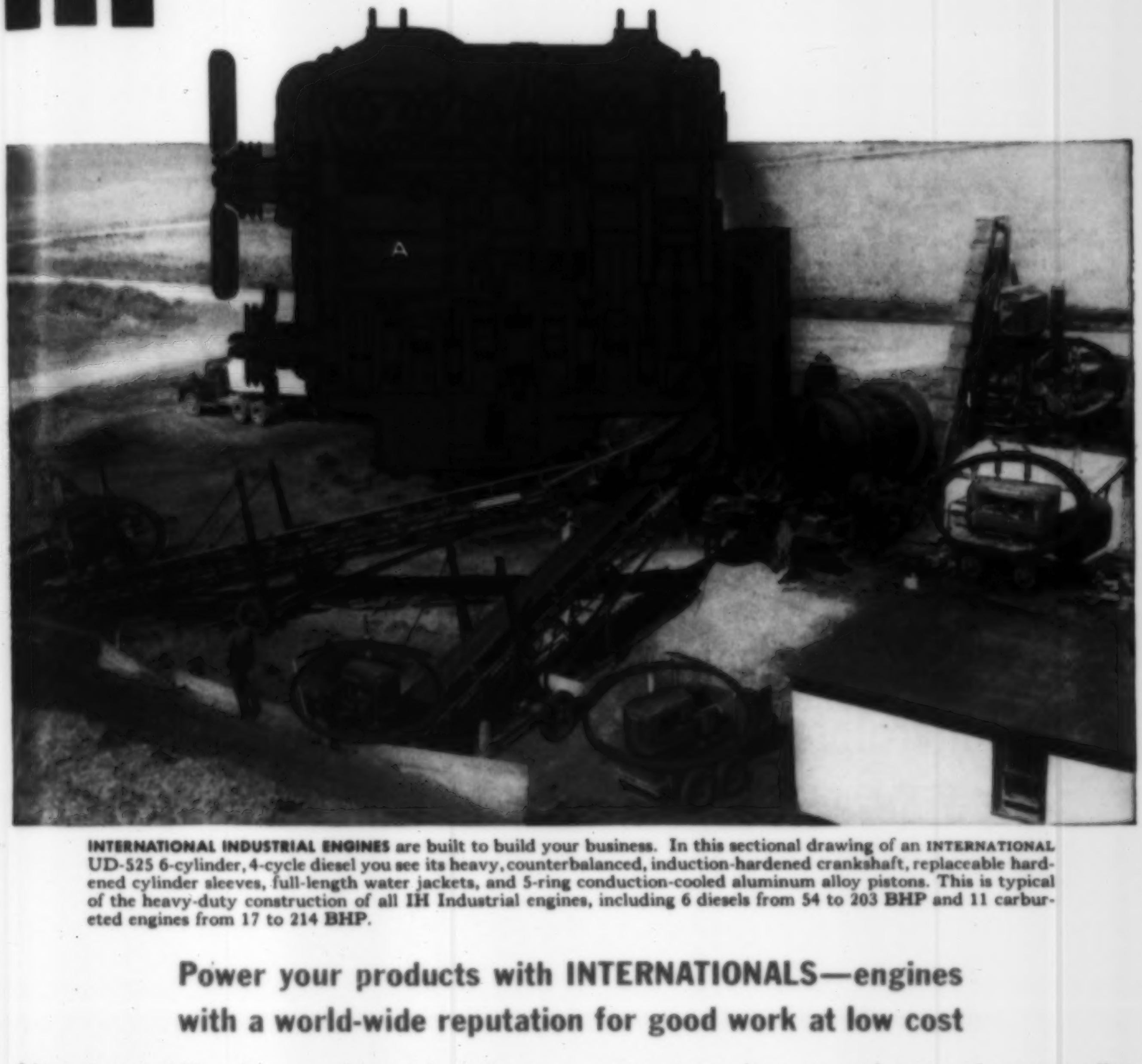
For more data circle MD-121, Page 211

Solenoid Valves

Type K solenoid valves employ stainless steel for all parts which come into contact with the media. Construction also includes cushioned closing, renewable Teflon disks and Guidon pilot valve seats, which aid in tight seating. Piston-pilot operated valves have full port openings and operate over a wide pressure range. The piston, pilot valve and spring are the only moving parts operating in the packless operating chamber. Waterproof molded coils withstand temperatures to 250 F; glass insulated, silicone impregnated coils are used for higher temperatures. Valves are available in $\frac{1}{2}$, $\frac{3}{4}$ and 1-in. sizes. Explosionproof coil



Power is Pre-Sold Power



INTERNATIONAL INDUSTRIAL ENGINES are built to build your business. In this sectional drawing of an INTERNATIONAL UD-525 6-cylinder, 4-cycle diesel you see its heavy, counterbalanced, induction-hardened crankshaft, replaceable hardened cylinder sleeves, full-length water jackets, and 5-ring conduction-cooled aluminum alloy pistons. This is typical of the heavy-duty construction of all IH Industrial engines, including 6 diesels from 54 to 203 BHP and 11 carbureted engines from 17 to 214 BHP.

Power your products with INTERNATIONALS—engines with a world-wide reputation for good work at low cost

Add to the saleability of your machines right at the design stage by powering your products with INTERNATIONAL engines, the heavy-duty power plants that are pre-sold to a world-wide market of power users.

The eighteen engines in the INTERNATIONAL line, for example, are the result of more than 50 years of IH engineering and manufacturing experience building a complete line of heavy-duty engines for construction and oil field equipment, for tractors, trucks and individual power unit applications.

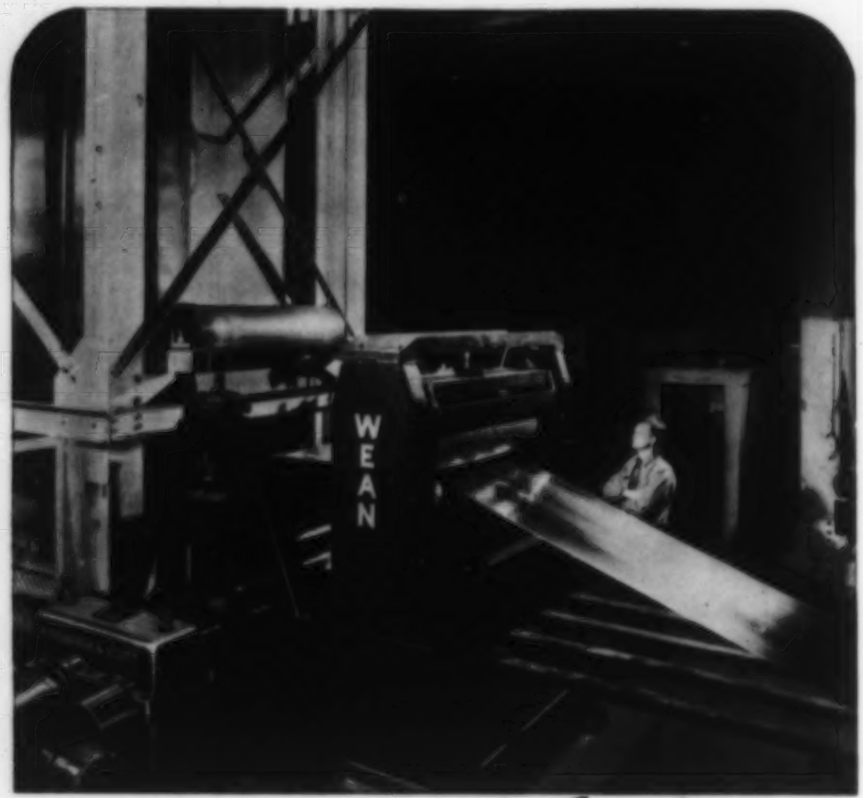
Cash in on this ready-made engine market, as more than 200 equipment manufacturers are already doing, by powering your machines with INTERNATIONALS. They will provide the dependable, durable, low-cost power your equipment must have to gain an expanding market.

Get product information on any of the 18 carbureted and diesel models in the IH line or the help of IH installation engineering by writing:

INTERNATIONAL HARVESTER COMPANY
Industrial Power Division **Melrose Park, Illinois**

INTERNATIONAL HARVESTER

INTERNATIONAL
INDUSTRIAL POWER
MAKES EVERY LOAD A PAYLOAD



...for continuous uninterrupted service

H & S Speed Reducers Are Used

The above illustration shows an H & S reducer driving the main pulling bridle in a Wean continuous tower type annealing line for tin plate at a large steel corporation. It replaces the batch annealing process and produces a much more uniform product . . . with a great saving in floor space. H & S reducers were selected for their excellent construction and reliability (*freedom from down time*).

This is only one instance where H & S is helping industry do a better job . . . our engineering department is always at your service.

THE HORSBURGH & SCOTT CO.
GEARS AND SPEED REDUCERS
5112 Hamilton Avenue
Cleveland 14, Ohio

Send note on Company Letterhead for 488-Page Catalog 49

housings and many speical assemblies are available. Made by **J. D. Gould Co., 730 E. Washington St., Indianapolis 2, Ind.**

For more data circle MD-122, Page 211

Impulse Counter

This electrical impulse counter can be preset for any number to 100,000. A double-pole, double-throw process control switch is thrown when the specified number is reached, and the counter is reset automatically. Resetting also can be effected by signal such as a pushbutton or manually by a lever. Counter may be reset during cycle without changing the setting. It provides a visible progress count. Device is also available for panel mounting and for stroke, revolution or measuring counting. An eight-digit totalizer is optional. Available from **Presin Co.,** 802 N. Fairfax Ave., Los Angeles 46, Calif.

For more data circle MD-123, Page 211

Load Control Relay

Very slight changes in input current to a machine or process drive motor can be detected by the MEK-2128 load control relay. Control can be used to correct the difficulty, stop the machine, adjust the feed, or sound an alarm. Effective in protecting machines from damaging overloads, it can also be used to indicate end of spark-out periods, to control feeds, to indicate wheel-glazing on grinding wheels, and to control injection molding presses. Units are designed to detect increases in current above preset load, although controls are available to detect

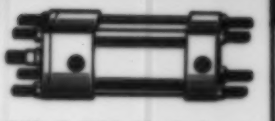
over 8,000 Different Cylinder SELECTIONS—

Miller AIR AND HYDRAULIC CYLINDERS AND BOOSTERS

"IN STOCK"

for immediate delivery

See Miller Bulletins A-105K (Air) and H-104K (Hydraulic) for Complete Dimensions and Engineering Data on these "in-stock" sizes and other Custom Miller Cylinders in bores up to 20" and strokes up to 22 feet.



A50 & H50—Tie Rods not extended beyond nuts.

A51 & H51—Tie Rods extended both ends (shown).

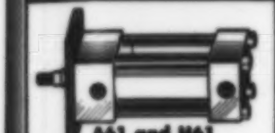
A52 & H52—Tie Rods extended. Cap End only.

A53 & H53—Tie Rods Extended. Rod End only.

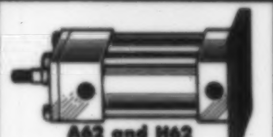
A54 & H54—Two Tie Rods extended at both ends.

"IN-STOCK" MODELS

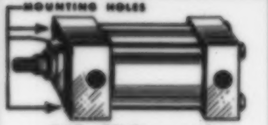
"A" Signifies Miller 200 psi Air Cylinders; "H", 2000 psi Hydraulic Cylinders. Interchangeable Mountings Are Shown In Red On Drawings.



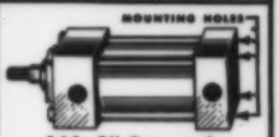
A61 and H61
Flange Mounting on Rod End
(A61 not available in 8" bore)



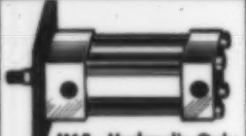
A62 and H62
Flange Mounting on Cap End
(A62 not available in 8" bore)



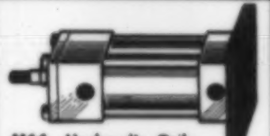
A63—8" Bore only
Flange Mounting on Rod End



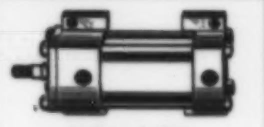
A64—8" Bore only
Flange Mounting on Cap End



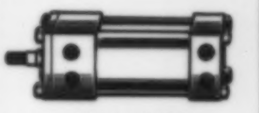
H65—Hydraulic Only
Flange Mounting on Rod End



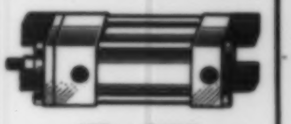
H66—Hydraulic Only
Flange Mounting on Cap End



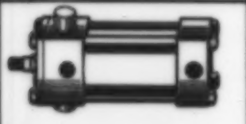
A72 and H72
Side Lug Mounting



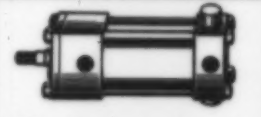
A74 and H74
Side Flush Mounting



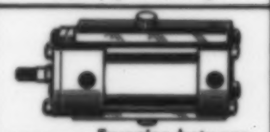
A77 and H77
Side or Foot Mounting



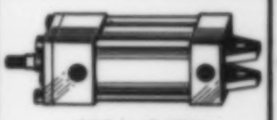
A81 and H81 Trunnion Mounting on Rod End



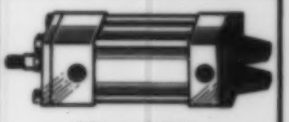
A82 and H82 Trunnion Mounting on Cap End



A83 and H83 Trunnion between Head and Cap
(one week delivery)



A84 and H84
Pivot Mounting



A86 and H86
Pivot Mounting

		BORES	ROD DIA.	ROD TURN DOWN & THREADS	"IN-STOCK" STROKES (in Inches)																					
IN STOCK BORES in Inches	AIR	1½	⅝"	7/16-20	Cushioned			3	4	5	6	7	8	9	10	11	12									
					Non-Cush.	1	2	3	4	5	6	7	8	9	10	11	12									
		2	⅝"	7/16-20	Cushioned			3	4	5	6	7	8	9	10	11	12	14	16	18	20	22	24	28	32	36
					Non-Cush.	1	2	3	4	5	6	7	8	9	10	11	12	14	16	18	20	22	24	28	32	36
		2½	⅝"	7/16-20	Cushioned			3	4	5	6	7	8	9	10	11	12	14	16	18	20	22	24	28	32	36
					Non-Cush.	1	2	3	4	5	6	7	8	9	10	11	12	14	16	18	20	22	24	28	32	36
		3¼	1"	¾-16	Cushioned			3	4	5	6	7	8	9	10	11	12	14	16	18	20	22	24	28	32	36
					Non-Cush.	1	2	3	4	5	6	7	8	9	10	11	12	14	16	18	20	22	24	28	32	36
		4	1"	¾-16	Cushioned			3	4	5	6	7	8	9	10	11	12	14	16	18	20	22	24	28	32	36
					Non-Cush.	1	2	3	4	5	6	7	8	9	10	11	12	14	16	18	20	22	24	28	32	36
		5	1"	¾-16	Cushioned			3	4	5	6	7	8	9	10	11	12	14	16	18	20	22	24	28	32	36
					Non-Cush.	1	2	3	4	5	6	7	8	9	10	11	12	14	16	18	20	22	24	28	32	36
		6	1⅜"	1-14	Cushioned			3	4	5	6	7	8	9	10	11	12	14	16	18	20	22	24	28	32	36
					Non-Cush.	1	2	3	4	5	6	7	8	9	10	11	12	14	16	18	20	22	24	28	32	36
		8	1⅜"	1-14	Cushioned			3	4	5	6	7	8	9	10	11	12	14	16	18	20	22	24	28	32	36
					Non-Cush.	1	2	3	4	5	6	7	8	9	10	11	12	14	16	18	20	22	24	28	32	36
	HYDRAULIC	1½	⅝"	7/16-20	Cushioned			3	4	5	6	7	8	9	10	11	12									
					Non-Cush.	1	2	3	4	5	6	7	8	9	10	11	12									
		2	1"	¾-16	Cushioned			3	4	5	6	7	8	9	10	11	12	14	16	18	20	22	24	28	32	36
					Non-Cush.	1	2	3	4	5	6	7	8	9	10	11	12	14	16	18	20	22	24	28	32	36
		2½	1"	¾-16	Cushioned			3	4	5	6	7	8	9	10	11	12	14	16	18	20	22	24	28	32	36
					Non-Cush.	1	2	3	4	5	6	7	8	9	10	11	12	14	16	18	20	22	24	28	32	36
		3¼	1⅜"	1-14	Cushioned			3	4	5	6	7	8	9	10	11	12	14	16	18	20	22	24	28	32	36
					Non-Cush.	1	2	3	4	5	6	7	8	9	10	11	12	14	16	18	20	22	24	28	32	36
		4	1¾"	1¼-12	Cushioned			3	4	5	6	7	8	9	10	11	12	14	16	18	20	22	24	28	32	36
					Non-Cush.	1	2	3	4	5	6	7	8	9	10	11	12	14	16	18	20	22	24	28	32	36
		5	2"	1½-12	Cushioned			3	4	5	6	7	8	9	10	11	12	14	16	18	20	22	24	28	32	36
					Non-Cush.	1	2	3	4	5	6	7	8	9	10	11	12	14	16	18	20	22	24	28	32	36

① ① ④ ③ ② ② ④ ③

"A" and "H" Models 82, 84 and 86 with strokes over 18" require stop tubes.

Column strength requires larger diameter piston rods for the following:

Air Cylinder Models A82, 84, and 86 with strokes inside area (1), when operated at 100 psi and over;

All hydraulic models with strokes inside area (2) and Models H82, 84, and 86 with strokes in area (4), when operated at 2000 psi and over;

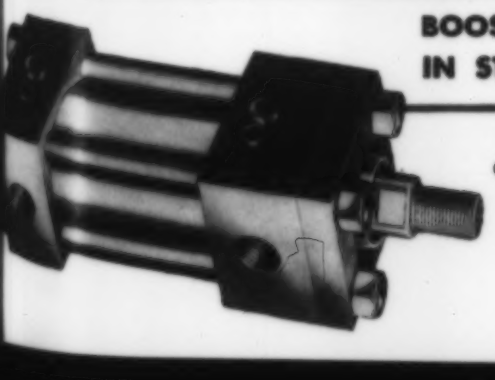
Models H82, 84 and 86 with strokes inside area (3), when operated at 1000 psi and over.

Depending upon Trunnion Pin location, "A" and "H" Models 83 with standard diameter piston rods can have longer strokes than Models 82, 84 and 86.

See Miller File #251 for oversize piston rod and stop tube requirements.

BOOSTERS IN STOCK

Immediate Delivery on the following Miller 25 to 1 Ratio Boosters (80 psi air input produces 2000 psi hydraulic oil output): Model B4, 5" bore, 1" dia. ram, 6" and 12" strokes; Reciprocating Booster Model DA77-RBA8, 5" bore, 1" dia. ram, 6" stroke. Also Booster Tanks, 5" dia., 6" and 10" heights.

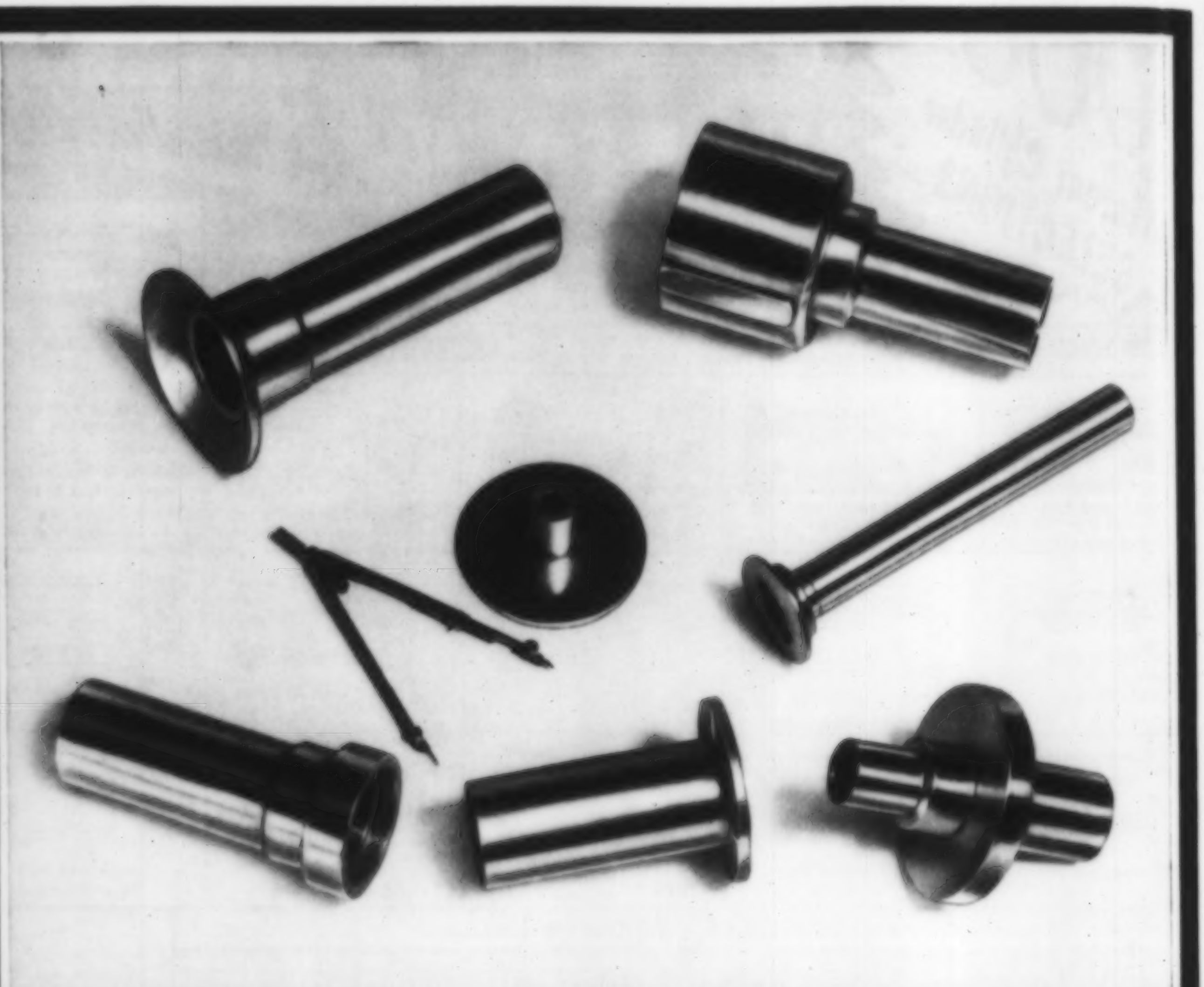


Write For Catalog and Stock Price List

MILLER FLUID POWER CO.

2006 N. HAWTHORNE AVE. • MELROSE PARK, ILL.

AIR & HYDRAULIC CYLINDERS • BOOSTERS • ACCUMULATORS
COUNTERBALANCE CYLINDERS



PICK ANY ONE, ALCOA CAN IMPACT IT IN ONE PUNCH

In a single press stroke, Alcoa forms seamless tubular parts like these with diaphragms, flanges, shoulders and ribs. And for parts like these, impact extrusion is the only economical method of one-operation forming. Alcoa Impacts combine the advantages of an extruded side wall and a forged bottom to give you ultimate lightness and strength.

If you have confined your thinking of impact extrusions to tooth-paste tubes and condenser cans, see what is being done today at Alcoa's Impact plant. For instance, we make a variety of nonsymmetrical parts; use strong alloys; produce heavy sections and long, thin tubular parts.

Your local Alcoa sales engineer offers unbiased help in your design problems. His intimate knowledge of the impact process may effect substantial savings to you. He is listed under "Aluminum" in the classified phone book. Aluminum Company of America, 1991 G Alcoa Building, Pittsburgh 19, Pennsylvania.

Your Guide to
Aluminum Value

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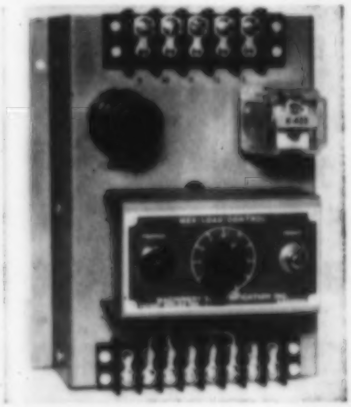
Fasten Aluminum With Alcoa® Aluminum Fasteners

Alcoa Makes Impact Extrusions to Your Specifications



load decreases, or changes both above and below desired limits. Made by **Machinery Electrification Inc.**, Northboro, Mass.

For more data circle MD-124, Page 211

Hydraulic Valve

Designed for use with ¾-in. ID pipe, this three and four-way hydraulic valve has oil passages with cross-sectional areas which are equal to or greater than the cross-sectional area of the pipe. Thus back pressure from restriction is minimized. When used with hydraulic motors, the valve exhibits a "feathering" characteristic; the motor operates smoothly at the extremes of its speed limits. The valve operates smoothly from "hold" position to full application of oil at 2000 psi. Made by **Century Engineering Co.**, Waukesha, Wis.

For more data circle MD-125, Page 211

Control Panel Enclosures

Completely liquid tight, NEMA type 12 sheet metal panel enclosures are made without holes and have welded seams and covers gasketed with neoprene sponge. Fif-

(*Continued on Page* 270)

TUTHILL SIMPLIFIES PUMP SELECTION

New Cataloging Plan Provides Practical Short-Cuts to Pump Specifications — Helps You Pick The Right Pump for the Purpose

If Your Specifications Call For . . .

a COOLANT PUMP that provides positive delivery, is self-priming and operates under high suction lift . . .

In capacities from 2 to 50 g.p.m.

. . . Write for Tuthill Catalog 104

Catalog 104 presents the Model M series of rotary, internal-gear positive displacement pumps with the exclusive Tuthill automatic internal-relieving feature for controlled pressure.

TUTHILL PUMPS FOR THE PURPOSE

TUTHILL PUMP COMPANY
Dependable Rotary Pumps since 1927
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Canadian Affiliate: Ingersoll Machine & Tool Co., Ltd. • Ingersoll, Ontario, Canada

Here's How the Revolutionary

Gilmer "TIMING"®

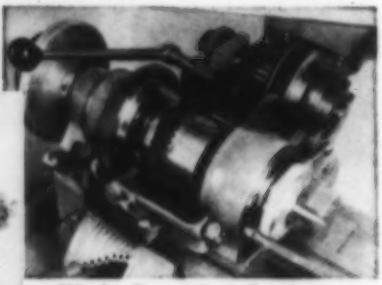
has been enthusiastically adopted by America's

MACHINE TOOL INDUSTRY

A 4"-wide "Timing" Belt drives the spindle of New Britain Model 126 Automatic Bar Machine.

MACHINE TOOL designers have found in the Gilmer "Timing" Belt Drive a superior means of transmitting power more quietly, more efficiently, more economically, with more precise synchronization, and at constant angular velocity. On metal cutting and grinding machines the "Timing" Belt Drive has shown the way to minimize vibration and tool chatter, resulting in finer surface finish. Shown here are only a few representative machine tools now making use of Gilmer "Timing" Belts on their most vital drives.

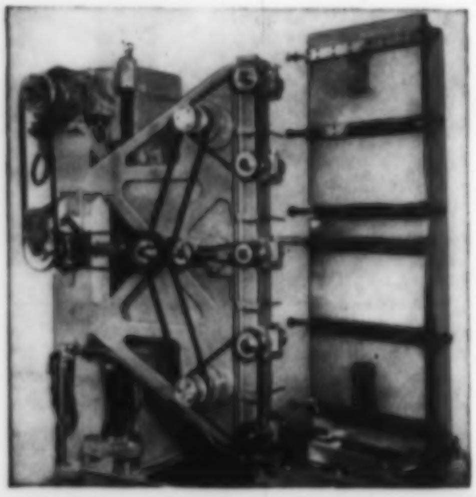
Ruesch #149 Gang Slitter employs 3 *stock* "Timing" Belt Drives from 20 HP motor.



Wade Precision Lathe uses "Timing" Belt spindle drive.

"Timing" Belt headstock drive on Van Norman Radial Grinder permits finer finishes.

Eight "Timing" Belt drives provide excellent carbide tool life and finishes on Pratt & Whitney Duplicator.

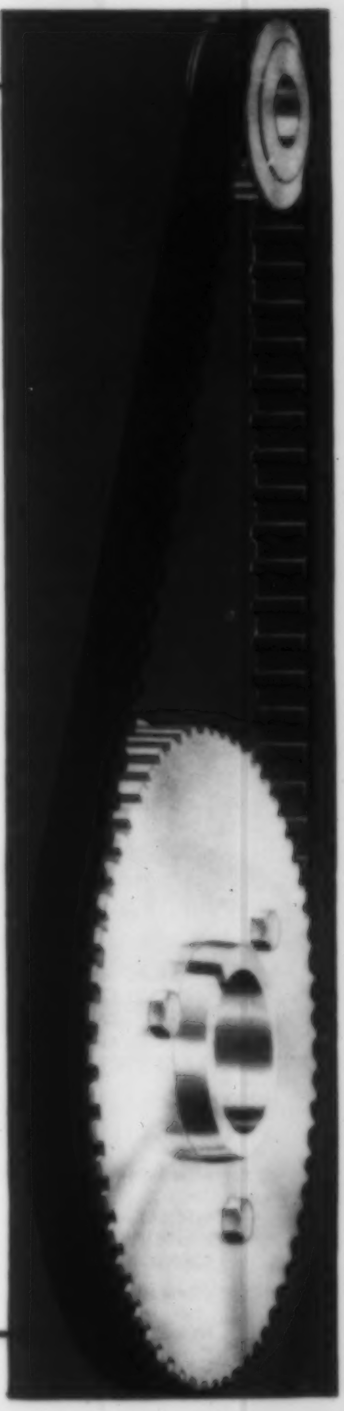


"Timing" Belts are used to drive Waterbury-Farrel Screw Head Slitting Machine.

NEW YORK BELTING & PACKING CO
Founded 1846

NYB & P

BELT DRIVE



Industry's New Power-Transmitting Medium

Sweeps away design restrictions

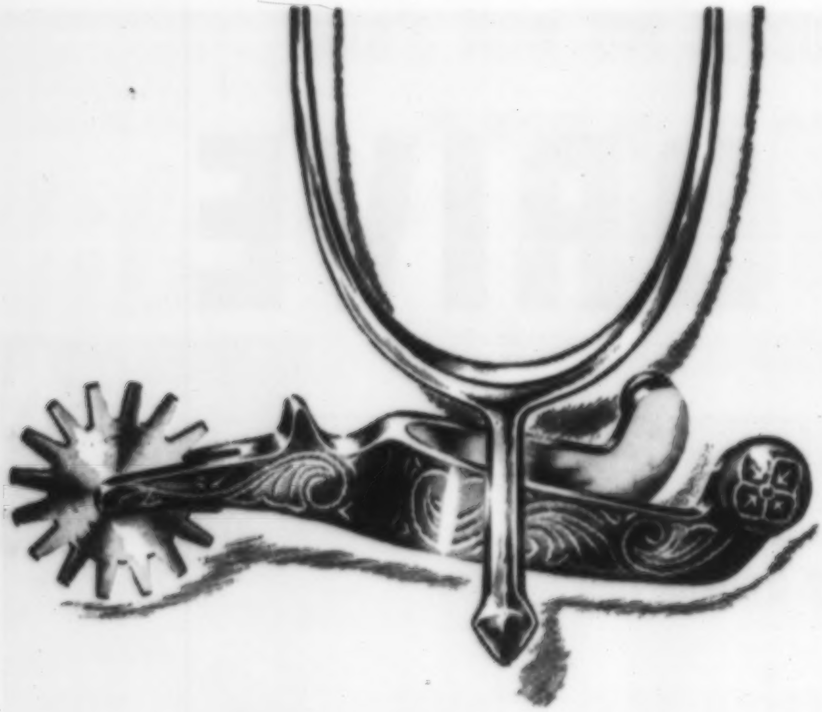
In one application after another, "Timing" Belt Drives have enabled machine designers to achieve basic engineering improvements—or to design entirely new machines—that were previously either impractical or impossible! For never before has there been a *positive drive* that combined all these desirable characteristics:

- **Requires no lubrication, no housings or lubricant guards.**
- **Maintains precise synchronization ("timing") between shafts.**
- **Provides speed ratios as high as 15 to 1 in a single step.**
- **Operates satisfactorily at speeds from inches per hour to 15,000 fpm.**
- **Permits use of very small diameter pulleys for ultra-compact drives.**
- **Has nearly 100% mechanical efficiency.**
- **Needs no initial tension. Lighter bearing loads permit lighter bearings.**
- **Does not stretch or lengthen with use; requires no take-up.**
- **Can be designed for zero backlash.**
- **Capacity ranges from 1/100 to 300 horsepower.**

These are but a few of the unique features of this amazing tooth-grip belt drive that is already in successful use on hundreds of thousands of machines. Full details and description are given in the 76-page Gilmer "Timing" Belt Manual, which lists hundreds of drives available promptly from stock. For your copy, call your nearby Gilmer "Timing" Belt Distributor. Or, if he isn't listed in the classified telephone directory, write to the address below.

NEW YORK BELTING & PACKING CO. 1 Market St., Passaic, N. J.

America's Oldest Manufacturer of Industrial Rubber Products



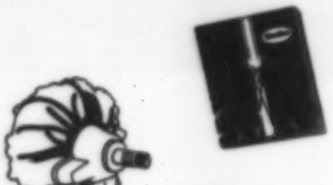
Choose one . . .

You can see at once that these spurs differ; serve different need. Suppliers differ. Titeflex was born and raised on a custom-engineering way of doing business. Fresh thinking comes naturally to them. Titeflex people like to tackle the tough ones.

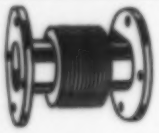
When you buy any Titeflex product you get something extra for your money—Titeflex interest in you. Take time to learn the difference. Send the coupon along today.

Titeflex

☐ Seamed and Seamless Metal Hose



☐ Ignition Harness and Shielding



☐ Precision Bellows

☐ Quick-Seal Coupling

TITEFLEX, INC.
INDUSTRIAL PRODUCTS DIVISION
508 Hendee Street, Springfield, Mass.

Please send me without cost information about the Titeflex products checked above.

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City__________ Zone_____ State_____

Left—Western spur with 16-point rowel Right—English spur with straight rowel

New Parts

(*Continued from Page 267*)

teen sizes range from 16 x 12 x 6 in. to 60 x 36 x 8 in. Enclosures have external mounting feet. A print holder is located on the inside of the continuous hinged cover, and a removable mounting panel for electrical equipment is furnished. Interior finish is baked white enamel and exterior is prime coated. Made by **Hoffman Engineering Corp.**, 1139 Tyler St., Anoka, Minn.

For more data circle MD-126, Page 211

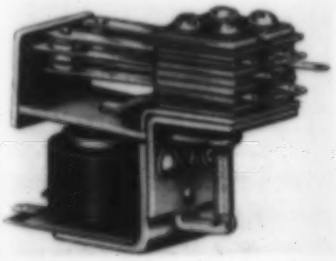
Switch Type Governors

Addition of a three-element speed sensitive switch to line of governors permits opening or closing of separate circuits at three different speeds in range of 1200 to 10,000 rpm. Although all trip speeds are factory preset to specifications, any of the three trip points can be adjusted after installation. Operating mechanism consists of rotating governor flyweights acting upon snap switches. Contacts are rated 10 amp at 115-v ac. Standard units are splashproof, and all parts are either plated or noncorrosive metal. Special waterproof and/or fungusproof types can be furnished. Made by **Synchro-Start Products Inc.**, 8151 N. Ridgeway Ave., Skokie, Ill.

For more data circle MD-127, Page 211

Motor Control Relay

Series 210-UM magnetic motor controller relay is available in any standard arrangement of contact



combinations from single-pole, single-throw, normally open, to double-pole, double-throw. Coil voltage is 115 v, 60 cycles. Contacts are rated at 115 v, 60 cycles, single phase, ¼-hp. Standard coil and contact terminals are lug type, tinned to facilitate soldering. Bakelite contact insulation is tested at 1500 v, 60 cycles. Made by **Guardian Electric Mfg. Co.,** 1621 W. Walnut St., Chicago 12, Ill.

For more data circle MD-128, Page 211

Electronic Timer

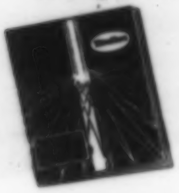
T-1 electronic timer operates with repeat accuracy of ±2 per cent. Timer can be used for interval, delayed action, repeat cycle and single cycle timing and can

be supplied with standard time ranges of 0.3 to 25 seconds or 0.5 to 50 seconds. The 270-degree dial assembly can be removed for remote operation. Isolated load contacts are rated 5 amp. Made by **Ferrara Inc.,** 8106 W. Nine Mile Rd., Oak Park 37, Mich.

For more data circle MD-129, Page 211

Hydraulic Spring

Self-contained dual action Hydra Spring is now available with a built-in valve for dampened return to cushion impact. It has a low-mass piston, provides high frequencies and is 2¾ in. diameter by 4¾ in. long, including a 1-in.



...to handle vibration,
temperature and corrosion headaches
in conveying applications

Do you have to conduct water, solutions, fuel, lubricants, oxygen or other gases or liquids between two points which may not remain fixed? Your answer is Titeflex flexible metal hose.

Titeflex offers you just about everything you could wish for in metal hose—seamed or seamless, braided or unbraided, a wide choice of alloys and fittings. And Titeflex has the originality and experience to simplify your design difficulties—the laboratory control and development engineering assistance you want behind you. All you have to do is send your drawing; we fill in the exact hose type required. ***Telephone or mail in the coupon for full information about metal hose and its uses, catalog #200.***

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TITEFLEX, INC.
Industrial Products Division
508 Hendee Street
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Your knowledge af metal hose applications may be helpful to us. Please send your complete catalog—without obligation.

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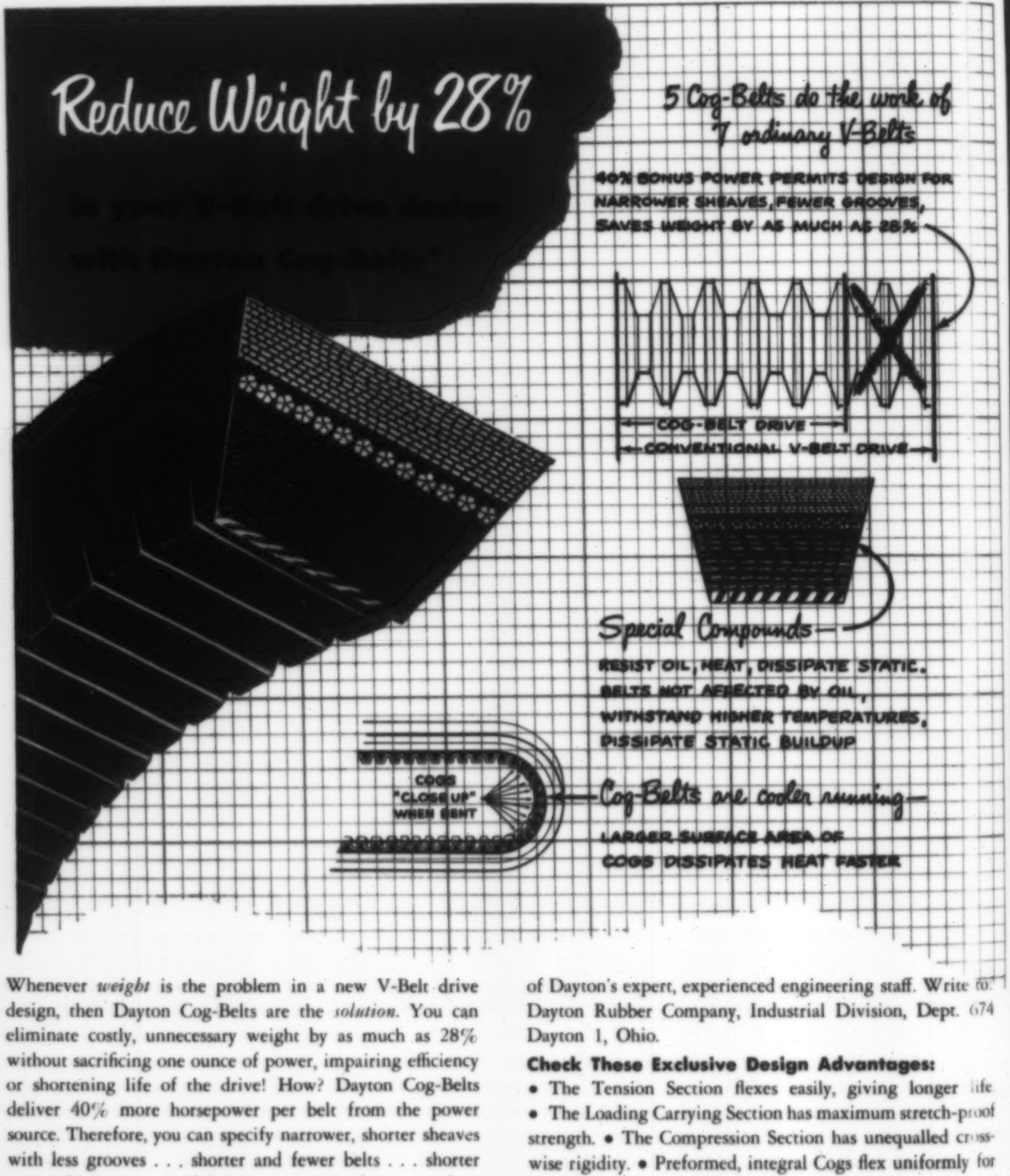
Reduce Weight by 28%
In your V-Belt drive design with Dayton Cog-Belts*
5 Cog-Belts do the work of 7 ordinary V-Belts
40% BONUS POWER PERMITS DESIGN FOR NARROWER SHEAVES, FEWER GROOVES, SAVES WEIGHT BY AS MUCH AS 28%
COG-BELT DRIVE
CONVENTIONAL V-BELT DRIVE
Special Compounds—
RESIST OIL, HEAT, DISSIPATE STATIC.
BELTS NOT AFFECTED BY OIL,
WITHSTAND HIGHER TEMPERATURES,
DISSIPATE STATIC BUILDUP
COGS "CLOSE UP" WHEN BENT
Cog-Belts are cooler running—
LARGER SURFACE AREA OF COGS DISSIPATES HEAT FASTER

Whenever *weight* is the problem in a new V-Belt drive design, then Dayton Cog-Belts are the *solution*. You can eliminate costly, unnecessary weight by as much as 28% without sacrificing one ounce of power, impairing efficiency or shortening life of the drive! How? Dayton Cog-Belts deliver 40% more horsepower per belt from the power source. Therefore, you can specify narrower, shorter sheaves with less grooves . . . shorter and fewer belts . . . shorter center distances . . . and lighter supporting frame members for a given power application. And in addition to saving weight, you save space and cost and gain compactness and power.

What's more, with patented and exclusive Dayton Cog-Belts, you can be assured of maintaining the superiority of your finished products. Your customers will also profit by trouble-free, low-cost power transmission and increased productivity.

For help on your drive design problem, take advantage of Dayton's expert, experienced engineering staff. Write to: Dayton Rubber Company, Industrial Division, Dept. 674 Dayton 1, Ohio.

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• The Tension Section flexes easily, giving longer life. • The Loading Carrying Section has maximum stretch-proof strength. • The Compression Section has unequalled cross-wise rigidity. • Preformed, integral Cogs flex uniformly for full grip. • Smooth, die-cut sides assure positive grip, full power.

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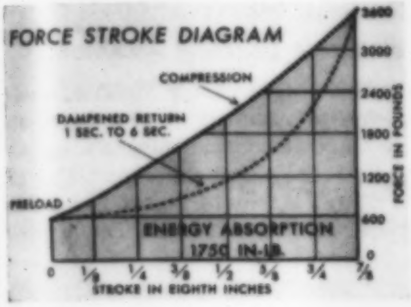
GOLDEN JUBILEE

Dayton 50 Rubber

YEARS OF PROGRESS

World's Largest Manufacturer of V-Belts

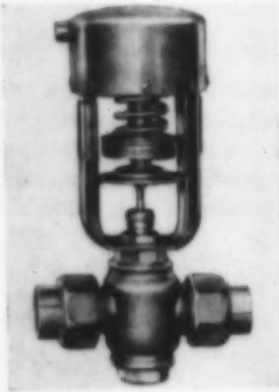
stroke. Spring uses compressible liquid called Wales Comproils and produces up to 3600 lb of force in a 1-in. stroke. It is also available with any spring and dampened return force combination. Comproils deliver maximum force at any position, including zero stroke, by built-in preloading and operate at high velocities without natural frequencies. Made by **Wales Strippit Corp.**, Hydra Spring Div., 345 Payne Ave., North Tonawanda, N. Y.



For more data circle MD-130, Page 211

Motor Valve

Equipped with a powerful cadmium-plated steel spring and two-ply seamless metal bellows, No. 992-D bellows motor valve is used to control the flow of steam, gas, oil, water and other fluids. Valve movement is linear. Built in either direct or reverse acting styles, the valve is available in sizes from ¼-in. to 4 in. and in a wide variety of types. Made by **Robertshaw-Fulton Controls Co.**, Fulton Sylphon Div., P. O. Box 400, Knoxville, Tenn.



For more data circle MD-131, Page 211

AFFILIATE OF GENERAL CERAMICS CORPORATION

Magnetic Amplifiers·INC

—announces its new

VARIABLE SPEED DRIVE

MAGNE-SPEED*

SIZE II — 3/4, 1 and 1-1/2 HP

SIZE I — 1/4, 1/3 and 1/2 HP

Stepless, instant starting, compact, 50:1 speed range, good regulation without tachometer, long life, virtually maintenance free service, low cost, fast response, reversibility, dynamic brake, local or remote control. Write for Bulletin S580-5-55.

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73 MODELS...7 PIPE SIZES...3 TYPES OF FILTER ELEMENTS...3 TYPES OF BOWLS

AUTOMATIC-DRAIN AIR FILTER
¼", ⅜", ½". For pressures up to 150 psi.; temperatures up to 120° F. Filter elements: 74-, 64- or 25-micron. Replaceable, transparent bowl. Series 11,200.

AIR FILTER
for pressures up to 250 psi. ¼", ⅜", ½". Replaceable, metal bowl. Filter elements: 74-, 64- or 25-micron. For temperatures up to 300° F. Series 22N.

SMALL BOWL AIR FILTER
¼", ⅜". For pressures up to 150 psi, temperatures up to 120° F. Replaceable, transparent bowl. 74-, 64- or 25-micron filter element. Series 12,200.

AIR LINE FILTERS
for pressures up to 150 psi. ¼" to 1" incl. Replaceable, transparent bowl in two sizes. 74-, 64- or 25-micron filter element. For temperatures up to 120° F. Series 22B.

MORE THAN 700,000 Norgren Filters put to use by industry

SMALL, METAL BOWL AIR FILTER
for pressures up to 250 psi. ¼", ⅜". 74-micron filter element. Permanent bowl. For temperatures up to 300° F. Series 0-552 and 0-554.

AIR FILTER
Permanent, metal bowl. ¾" to 1½" incl. 74-micron filter. For pressures up to 250 psi; temperatures up to 300° F. Series 560.

AIR PURIFIER
for exceptionally thorough removal of moisture. 74-micron Wire Screen and Yarn filter elements. Replaceable, transparent or metal bowls. ¼". Series 21B and 21N.

FILTER-REGULATOR UNIT
Automatically filters air and regulates air pressure. Replaceable, transparent or metal bowl. ¼", ⅜". Series 5A and 5N.

LUBRO-CONTROL UNIT (Model 3745A-2) typical combination of Norgren Automatic-Drain Filter, Pressure Regulator and Micro-Fog Lubricator.

Phone the Norgren representative listed in telephone directory classified section under "Norgren Pneumatic Products" or

C. A. Norgren CO.
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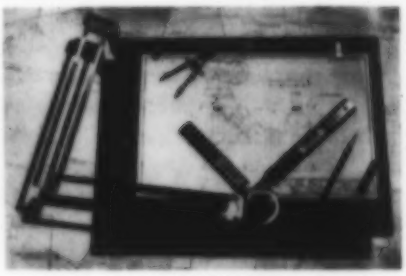
...shows latest developments in filters with data on Norgren's complete line of oil-fog lubricators, pressure regulators, valves, hose assemblies.

ENGINEERING DEPARTMENT EQUIPMENT

Portable Drafting Machine

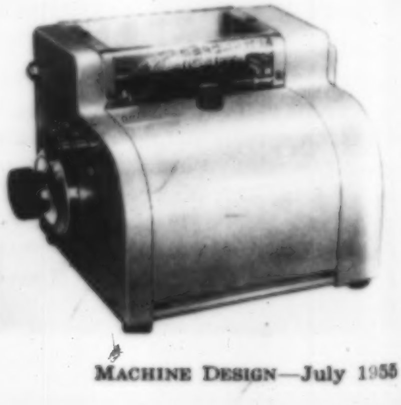
Model B portable drafting machine accommodates drawings up to 12 x 18 in. Various scales can be attached to the machine. The 15 x 20-in. Masonite board has three paper-holding clamps. The hinged mounting bracket of the parallel mechanism is provided with thumbscrew adjustment. A detachable protractor is marked in 2-deg graduations to 180 deg, reading 90 deg each side of zero. The protractor locks at any angle. Made by **Drafting Equipment Co.,** 504 Randolph St., Meadville, Pa.



For more data circle MD-132, Page 211

Fixed Stylus Recorder

Adaptable to analog, digital and sequential on-off reading, the R-1201-1 miniature fixed-stylus recorder provides 210 channels of information on a 5-in. wide Teledeltos chart. Chart speed of this direct-writing instrument is continuously adjustable from ¼-in. per



Norgren ...a complete line of PRESSURE REGULATORS

to Improve Performance, Reduce Wear of Air-Operated Equipment

MORE THAN 1,100,000 NORGREN REGULATORS PUT TO USE BY INDUSTRY

Reducing compressed air line pressures to proper working pressure for each piece of air-operated equipment is essential for high operating efficiency, long equipment life, and low maintenance costs.

More than 1,100,000 Norgren Regulators which have been put to use by industry prove the advantages of specifying Norgren for efficient, economical pressure regulation.

Nearly 400 standard models to meet your needs plus many others designed to meet specific performance requirements

Air Regulators
Reduce line pressures as high as 400 psi to desired working pressure. Four spring ranges to choose from for best performance — 50, 75, 125 or 250 psi maximum delivery. ⅛'' through 1'' pipe sizes. Series 2A.

Relieving-Type Air Regulators
Reduce line pressures as high as 400 psi to desired working pressure. Four spring ranges to choose from for best performance — 50, 75, 125 or 250 psi maximum delivery. The relieving feature protects connected equipment against abnormally high pressures. ⅛'' through 1'' pipe sizes. Series 2AX.

Precision Air Regulators, Relieving Type
Reduce line pressures as high as 400 psi to desired working pressure. Air flow up to 2 cfm with 30 psi maximum delivery. Also for flows of less than 1 cfm with maximum delivery pressures of 60 or 120 psi. ¼'' pipe size. Series 11,400.

Low Capacity Regulators for Air or Liquids
Reduce line pressures as high as 400 psi to desired working pressure. Choice of 2 spring ranges for best performance — 50 or 175 psi maximum delivery. 2 inlet ports and 3 outlet ports. ¼'' pipe size. Series 3A2-B.

Pilot-Controlled Air Regulators, Integral Type
Extreme precision over wide operating range. Reduce line pressures as high as 400 psi to desired working pressure from 2 psi to 120 psi. Three spring ranges to choose from for best performance—30 psi, 60 psi or 120 psi maximum delivery. ½'', ¾'', 1'' pipe sizes. Series 20AC.

Pilot-Controlled Air Regulators, Remote Control Type. Extreme precision over wide operating range. Reduce line pressures as high as 400 psi to desired working pressure from 2 psi to 120 psi. Three spring ranges to choose from for best performance—30 psi, 60 psi or 120 psi maximum delivery. ½'', ¾'', 1'' pipe sizes. Series 20AA.

Low Pressure Air Regulators
Reduce line pressures as high as 250 psi to desired working pressure. Choice of 2 spring ranges for best performance—40 or 60 psi maximum delivery. ¼'' pipe size. Series 1505.

Butane Pressure Regulators
For primary stage pressure regulation on industrial and large domestic applications. Reduce line pressures as high as 250 psi to desired working pressure up to 50 psi. ½'', ¾'', 1'' pipe sizes. Series 2E.

Cylinder Gas Pressure Regulators
Single-stage regulators to reduce cylinder gas pressures as high as 3000 psi to desired working pressure. Choice of four spring ranges for best performance — 50, 75, 175 or 450 psi maximum delivery. Close, constant pressure control. 2 inlet ports, 3 outlet ports. ¼'' pipe size. Series 4C and 6C.

Liquid Pressure Regulators
For lines carrying water, oil, non-corrosive liquids up to 200° F. Reduce line pressures as high as 400 psi to desired working pressure. Choice of four spring ranges for best performance—50, 75, 125 or 250 psi maximum delivery. 5 pipe sizes—⅛'' to 1'' inclusive. Series 2H.

Steam Pressure Regulators
For lines carrying saturated steam and hot water with temperatures up to 450° F. Reduce line pressures as high as 400 psi to desired working pressure. Choice of four spring ranges for best performance—50, 75, 125 or 250 psi maximum delivery. ½'', ¾'', 1'' pipe sizes. Series 2B.

Regulator-Filter Unit
Automatically filters air and regulates air pressure. Replaceable, transparent or metal bowl. Choice of 3 filter elements. With or without pressure gauge. ¼'' and ⅜'' pipe sizes. Series 5A and 5N.

Phone the Norgren representative listed in telephone directory classified section under "Norgren Pneumatic Products," or write ...

C. A. Norgren CO.
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Includes latest developments and complete data on Norgren Pressure Regulators, Oil Fog Lubricators, Air Filters, Valves, Hose Assemblies.

Nothing else needed

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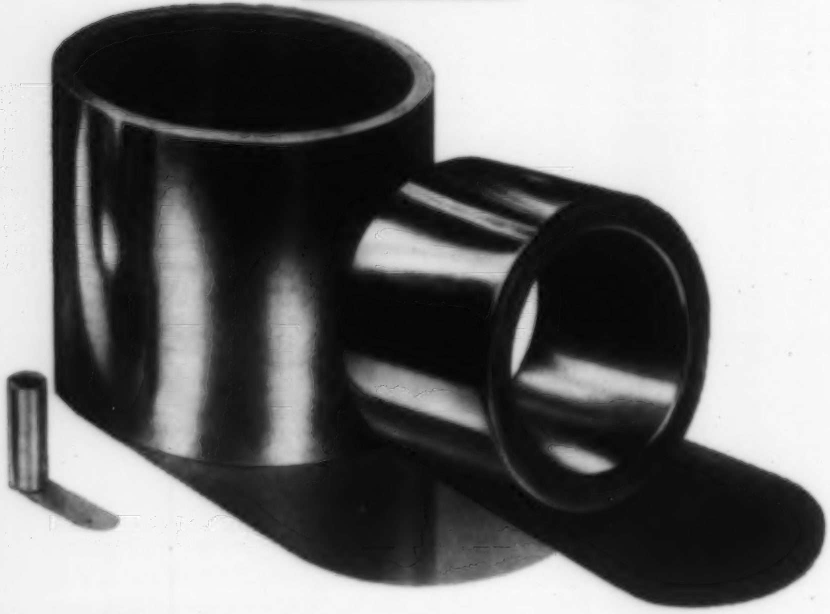
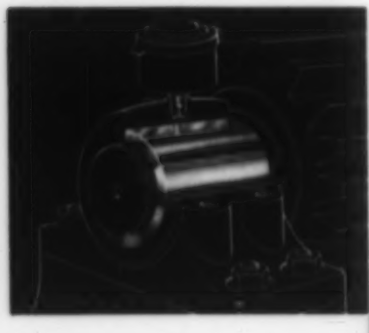
BUNTING BEARINGS



The Cast Bronze Bunting Bearing is delivered ready for installation—with the easy assembly in housing and on shaft all that is necessary. No lock nuts, lock washers, end covers are required to increase initial cost and assembly cost. Bunting engineers will gladly aid you in making specifications for the Bunting Bronze Bearing that exactly meets your need. There is a Bunting engineer near you for consultation, or write our Product Engineering Department at Toledo.



Where the Bunting Bearing is the floating type it is inserted by hand. Where the pressed—in type is employed, the bearing is simply pressed into the gear, gear box, lever or housing.

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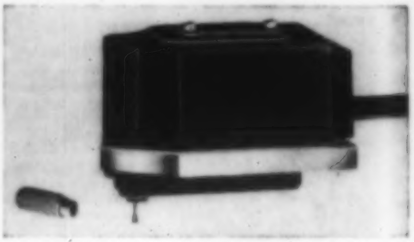
second to 5 in. per second. Magazine capacity is 100 ft. Quantitized inputs in either unidigital or decidigital form appear on the electrosensitive chart as visible traces which can be reduced manually or automatically. The recording medium provides a dry, permanent record which does not require processing and is not affected by light, fungus or atmospheric temperature changes. Unit operates on 115-v, 60-cycle power. Made by **Radiation Inc.**, Melbourne, Fla.

For more data circle MD-133, Page 211

Vibration Pickup

Sensitive probe of this Type 115 hand-held vibration pickup makes it suitable for exploring surfaces, bearings and lightweight objects and for detecting vibration accurately for analysis and measurement. The probe, attached to a pivoted coil moving between Alnico V permanent magnets, transmits motion from a vibrating surface to the coil, to cause motion and a generated voltage corresponding to the motion. Signal is generally run through leads to a vibration meter, recorder, spectrum analyzer or other instrument. Made by **MB Manufacturing Co. Inc.**, 1060 State St., New Haven 11, Conn.



For more data circle MD-134, Page 211

Creep-Testing Machine

Compact and easily maintained, model BJL-1 dynamic creep-testing machine is designed for testing metals for creep and fatigue at ambient and elevated temperatures. A static force up to 5000 lb and an alternating force of 0 to plus and minus 4000 lb at 3600 cpm, with a maximum amplitude of 0.050-in., can be applied. Creep up to 0.375-

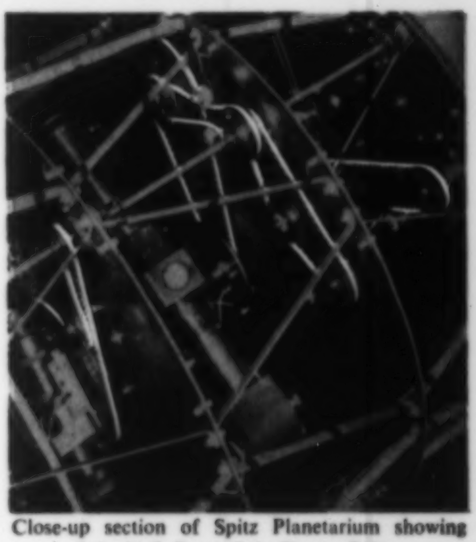
Keeping the planets in their orbits...
with U. S.
Timing Belts

Planetarium constructed by Spitz Laboratories, Inc., Elkton, Md., for the city of Montevideo, Uruguay, showing the heavens as seen looking southward from Montevideo.

The earth spins on its axis more than 10,756.265 times in the interval it takes Saturn to make one trip around the sun. Today there is a new planetarium so *accurate* that it shows the relative speeds of the sun, moon and the visible planets of the solar system moving in the same proportionate speed as they do in the real sky.

To achieve such amazing precision, Spitz Laboratories, Inc., makers of most of today's planetariums, uses United States Rubber Company's PowerGrip *Timing* Belts. On each unit, 13 of these belts drive the mechanisms for 8 solar system bodies with pin-point, split-second accuracy. These belts have teeth which fit into the pulleys, permitting a *completely controlled* quiet movement with absolutely no slippage or creeping. At the lowest speeds of these belts it is almost impossible for the human eye to detect any movement. Spitz Laboratories says it would be impossible to build so efficient a time and space machine without the U. S. PowerGrip *Timing* Belt.

Any product or manufacturing process that requires the transmission of power can be improved with the revolutionary PowerGrip *Timing* Belt. Appliance manufacturers for instance, find that U. S. PowerGrip permits a more streamlined product, greater efficiency, and more sales. Get in touch with any of our 27 District Sales Offices or write to address below.



Close-up section of Spitz Planetarium showing some of the U. S. PowerGrip *Timing* Belts.

"U. S." Research perfects it... "U. S." Production builds it... U. S. Industry depends on it

UNITED STATES RUBBER COMPANY

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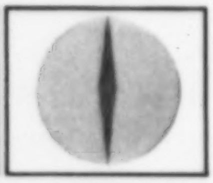
(Advertisement)

A composition that is almost twice as hard as the hardest steel . . . KENNAMETAL*

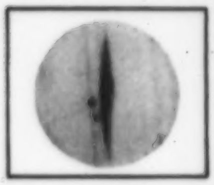
Kennametal is the registered trademark of a series of hard alloys of tungsten, tungsten-titanium, and tantalum carbides. These compositions are the *hardest* practicable metals made by man. In scratch hardness tests, these hard carbide particles are between sapphire and diamond. On the Rockwell "A" Scale, different Kennametal grades test from 90.0 to 93.0, while that of HSS 18-4-1 heat-treated steel tests a maximum of 85.0. The Knoop Test gives 2100 (K100) for Kennametal and 800 (K100) for steel.

K8 Tungsten carbide

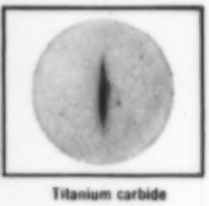

18-4-2 Steel

Photomicrographs above show results of Knoop hardness test on Kennametal K8 (left) and HSS 18-4-2 steel (right) at 100g. Impression in the Kennametal is only about half of that on the steel.

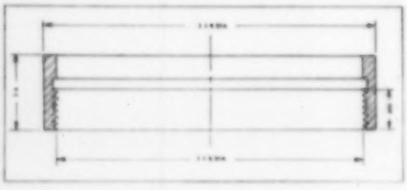
Photomicrographs below are of Knoop tests on grains of carbide ingredient of Kennametal. Knoop test numbers (at 100g) are: tungsten carbide, 1900; tungsten-titanium carbide, 2200; titanium carbide, 2500. These tests show those carbides are from two to three times as hard as steel in the absolute scale of Kgs per square mm of area of impression.


Tungsten carbide

Tungsten-titanium carbide

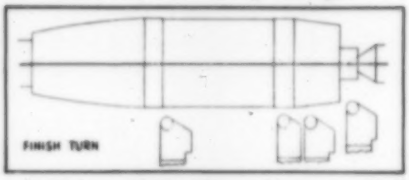

Titanium carbide

Extreme Hardness of KENNAMETAL Utilized by Designers



A West Coast manufacturer switched to solid Kennametal tungsten-titanium carbide tools for internal threading of stainless steel rings, jumped production from 35 to 40 pieces between grinds to 80 to 100 pieces with Kennametal. And the latter showed no cratering and only slight edge wear requiring only light grinding.

A manufacturer of aircraft landing gears uses the hardest grade of Kennametal cutting edges for interrupted cutting of SAE-4340 steel (220,000 psi tensile strength), at 1 ½ times greater speeds and with over 10 times longer tool life. Both sides of 54 pieces are rough cut and finish cut between grindings.



2400 to 3600 (depending on shell hardness) 90 mm shells are finished-turned using the hardest grade Kennametal before regrinding is required.

Perhaps KENNAMETAL's Extreme Hardness Can Help You, Too

Together with absolute hardness goes surprisingly greater resistance to wear and deformation. It is vital to innumerable industrial applications. Perhaps it is the characteristic you need to get YOUR idea off the drawing board and into production. It is worth investigating. Write to KENNAMETAL INC., Latrobe, Pennsylvania, and ask for Booklet B-111.

*Registered Trademark

7280

INDUSTRY AND
KENNAMETAL
. . . *Partners in Progress*

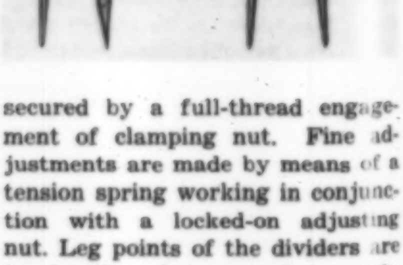
Engineering Equipment

in. can be accommodated. A separate cabinet houses all controls and controllers for the basic machine and the high-temperature unit and also accommodates the required instrumentation for temperature and creep recording. Made by **Ivy Co.**, 15 Merwin St., Norwalk, Conn.

For more data circle MD-135, Page 211

Wing Type Dividers

Divider designated No. 57, right, has two solid legs for scribing circles or arcs on hard or rough surfaces. No. 58 can function as a compass when its removable leg is replaced by a pencil. Settings are secured by a full-thread engagement of clamping nut. Fine adjustments are made by means of a tension spring working in conjunction with a locked-on adjusting nut. Leg points of the dividers are hardened and tempered to withstand hard usage. Each model is available in 6 and 8-in. sizes. Made by **Stanley Works**, 195 Lake St., New Britain, Conn.



For more data circle MD-136, Page 211

The Carry Cool Portable Room Cooler is manufactured by the Utility Appliance Corp., Los Angeles, Calif. It features a 2-speed fan, 3-gal. water reservoir, air filter and 12" fan blade. The Carry Cool can be used to cool or exhaust air. The Dylene polystyrene grille is molded by the Mutual Plastic Mold Co., Los Angeles, Calif.

Complex Safety Grille

made quickly with 22-oz. shot of fast-flowing Dylene* polystyrene

It takes an intricate die to form this fan grille, and it takes a fast-flowing plastic to fill all 27 of the ½"-deep louvers. A 22-oz. shot of medium impact Dylene polystyrene by Koppers did the job—quickly, economically. The attractive safety grille is light weight, easy-to-clean and impact-resistant.

Many manufacturers reduce costs and add color to their products by using Dylene housings, knobs, grilles and frames. You can mold Dylene plastic in any shape you need. And it *keeps* its bright, shiny look because the color goes clear through the plastic.

Wherever you need a material with high impact resistance along with bright colors, low water absorption, light weight and easy moldability, Dylene polystyrene is the right choice. For more information about this useful plastic write Koppers Company, Inc., Chemical Division, Dept. MD-75, Pittsburgh 19, Pennsylvania.

**Koppers Trademark*

KOPPERS ®

Koppers Plastics

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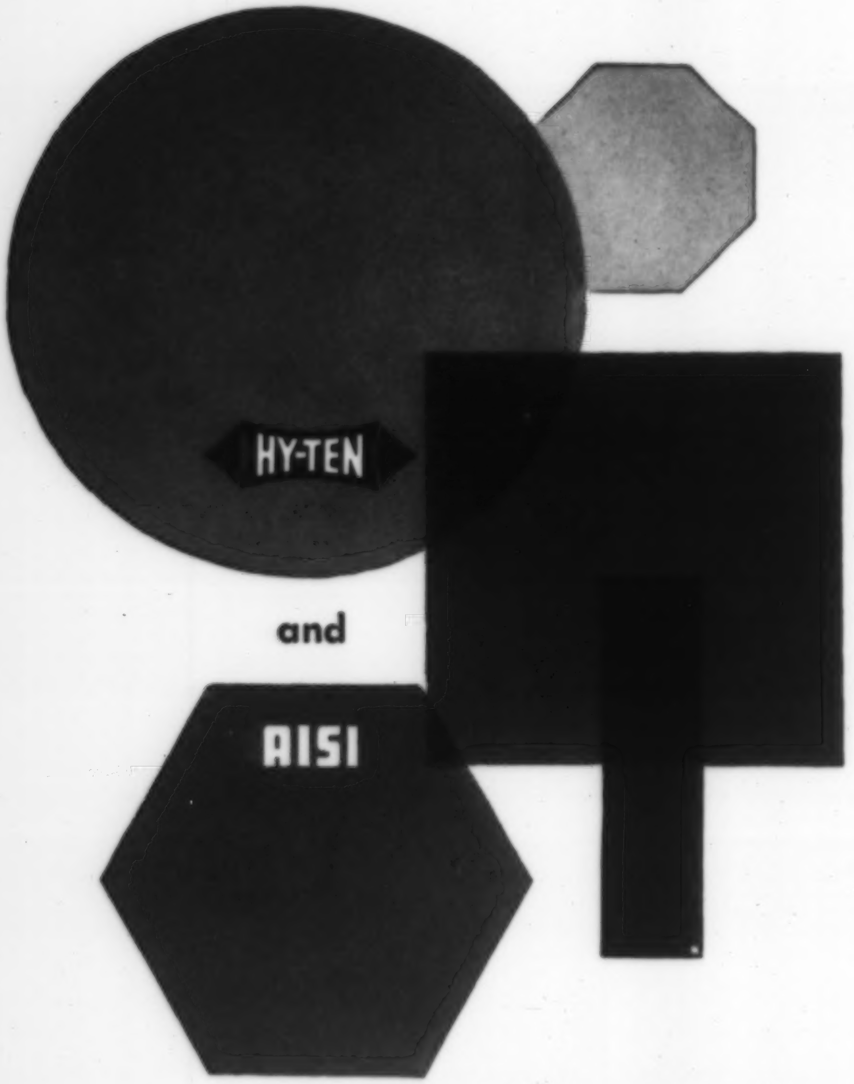

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THE ENGINEER'S Library

Recent Books

Vibration Problems in Engineering. *By S. Timoshenko, professor emeritus of engineering mechanics, in collaboration with D. H. Young, professor of engineering mechanics, Stanford University; 478 pages, 6 by 9 inches, clothbound; published by D. Van Nostrand Co. Inc., New York; available from* MACHINE DESIGN, *$8.75 postpaid.*

Now in its third edition, this textbook develops fundamentals of the theory of vibration and illustrates their application to the solution of technical problems by various examples. Vibration problems include balancing of machines, and torsional vibration of shafts, geared systems and turbine blades.

The first chapter is devoted to harmonic vibrations of systems with one degree of freedom. Chapter 2 deals with nonlinear vibrations and variable spring characteristics. Chapters 3 and 4 are concerned with systems having several degrees of freedom. Chapter 5 covers vibrations of elastic bodies, including combined bending and torsional vibration of beams.

•

Magnetic Amplifiers. *By H. F. Storm, General Engineering Laboratory of General Electric Co., also adjunct professor of electrical engineering, Rensselaer Polytechnic Institute; 565 pages, 5¾ by 9 inches, clothbound; published by John Wiley & Sons Inc., New York; available from* MACHINE DESIGN, *$13.50 postpaid.*

Purpose of this book is to explain fundamentals of the operation of magnetic amplifiers and to illustrate principal uses, along with theoretical and practical data on core materials, core-making techniques and metallic rectifiers. It is concerned mostly with single-phase amplifiers. It begins with the simplest form—the ordinary saturable reactor—and progresses to the higher forms, finally arriving at the so-called self-saturated magnetic amplifier. Servo-block diagrams illustrate integration of magnetic amplifiers into servo systems.

Containing 29 chapters by the author and several of his associates, the five parts of the book cover magnetics, theory of magnetic amplifiers, components, applications and saturating reactors.

•

The Properties of Glass. *By George W. Morey, staff member, geophysical laboratory, Carnegie Institution of Washington; 601 pages, 6 by 9 inches, clothbound; published by Reinhold Publishing Corp., New York; available from* MACHINE DESIGN, *$16.50 postpaid.*

This second edition emphasizes physical properties of glass as functions of composition. New material on complex and commercial glasses has been included, as well as new sections on effect of heat treatment on properties of glass, and of absorbed radiation. Various aspects of glass covered in 20 chapters include history and definition, devitrification, composition, chemical durability, viscosity, thermal conductivity, density, coefficient of expansion, elastic properties, strength, thermal endurance, hardness, optical properties, electrical conductivity, dielectric properties, magnetic properties and constitution.

•

Design of Machine Elements. *By V. M. Faires, professor of mechanical engineering, North Carolina State College; 574 pages, 6 by 9 inches, clothbound; published by The Macmillan Co., New York; available from* MACHINE DESIGN, *$10.00 postpaid.*

The third edition of this book has been developed to be more useful to practicing engineers as well as to students. Emphasis is on adaptation of theory to practical design. Treatment of variable

(*Continued on Page 286*)

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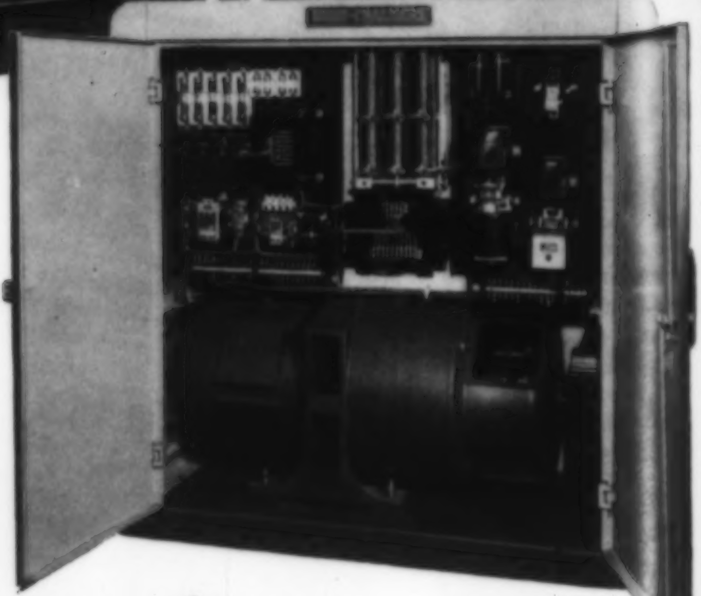

Size 2 packaged drive, 25 hp, with electronic speed regulation ¼ of 1% based on top speed, 3550/50 rpm.

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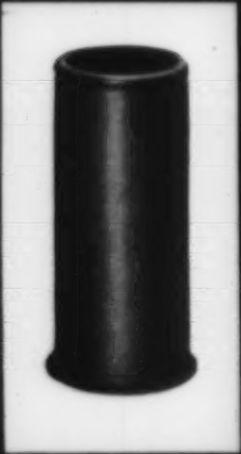

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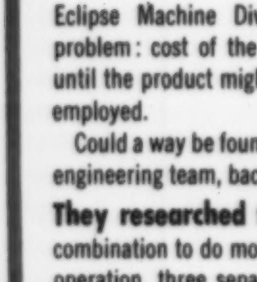

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The Engineer's Library

(*Continued from Page* 283)

stresses and fatigue has been expanded, as has coverage of mechanical properties of materials. Also new is an explanation of fundamentals of rolling bearings.

Subjects covered in 22 chapters include stress analysis; materials and their properties; tolerances and allowances; variable loads and stress concentrations; screw fastenings; thin-shell cylinders, riveted joints; springs; columns and power screws; combined stresses; shaft design; keys and couplings; journal and plane-surface bearings; ball and roller bearings; flat belts and pulleys; V-belts, chains and wire ropes; spur, helical, bevel and worm gears; brakes and clutches; welding; and miscellaneous problems.

New Standards

A List of American Standards—1955 Edition. 48 *pages,* 8¼ *by* 11 *inches, paperbound; copies available from American Standards Association,* 70 *E.* 45 *St., New York* 17, *N. Y.*

This publication lists and indexes about 1500 American Standards, including 153 mechanical, 272 electrical, 74 petroleum products, 62 metallurgy, and others. A separate section on consumer goods contains an index of standards for household appliances, furnishings, etc.

•

1954 Supplements to Book of ASTM Standards. *Seven volumes,* 6 *by* 9 *inches, paperbound; available from American Society for Testing Materials,* 1916 *Race St., Philadelphia* 3, *Pa.,* $3.50 *per part, or* $24.50 *for the complete set of seven parts.*

These supplements give in their latest form 415 specifications, tests and definitions which either were issued for the first time in 1954 or revised since their appearance in the 1952 Book of ASTM Standards or the 1953 Supplements. The parts comprising the complete supplement set are:

Part 1—Ferrous Metals; 89 stand-

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American Adjustable-Diameter Sheaves are easy to install or remove; have patented double-taper hubs to lock sheave to shaft, flanges to hub, in a tight wedge-grip. Flanges move simultaneously for perfect V-belt alignment. Dynamic balancing eliminates vibration.

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Power Transmission by

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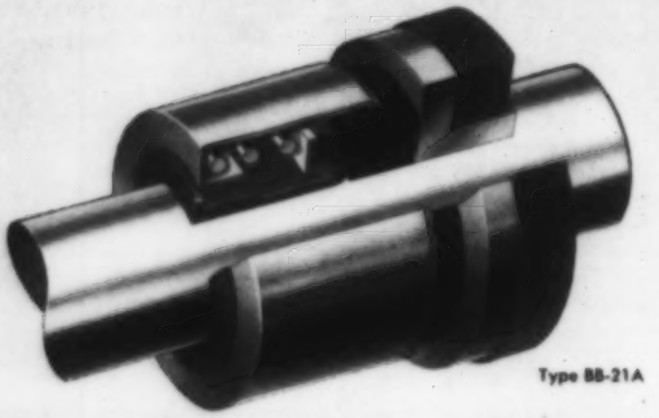

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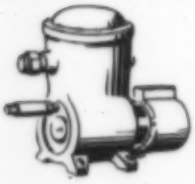

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Part 6—Rubber, Plastics, Electrical Insulation; 66 standards, 532 pages.

Part 7—Textiles, Soap, Water, Paper, Adhesives, Shipping containers; 38 standards, 296 pages.

Association Publications

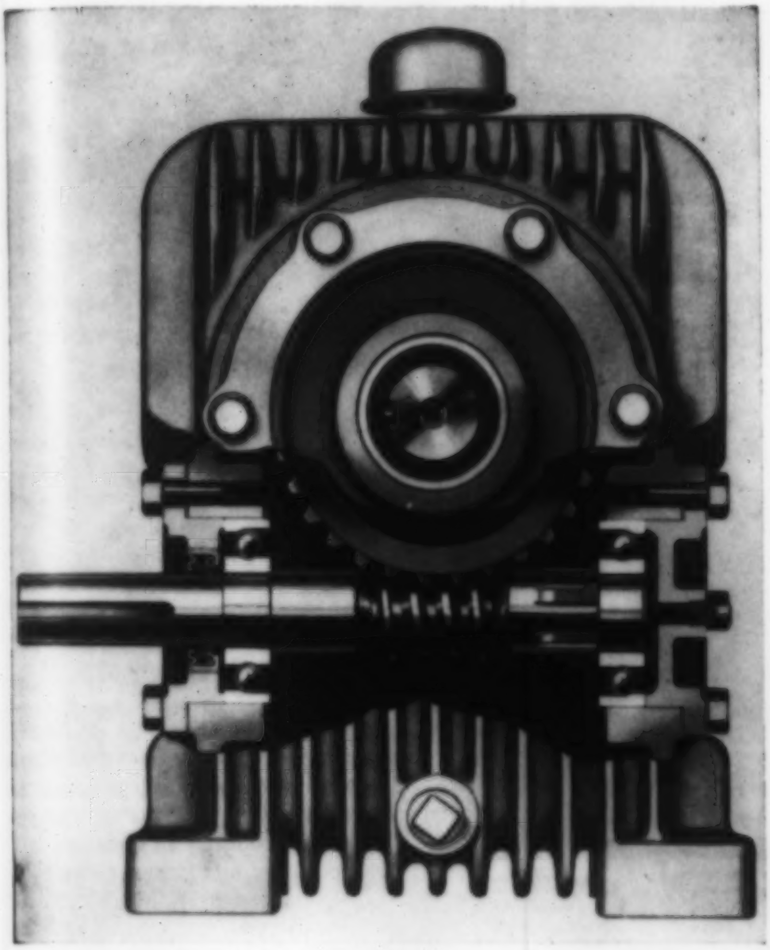
1953 References on Fatigue. *ASTM Special Technical Publication No. 9-E; 34 pages, 8½ by 11 inches; paperbound; available from American Society for Testing Materials,* 1916 *Race St., Philadelphia* 3, *Pa.,* $1.85 *per copy.*

This publication is a list of about 250 references to articles published in 1953 dealing with fatigue. It was sponsored by ASTM Committee E-9 on Fatigue. Brief abstracts of the articles have been included when readily available. References are so arranged that sheets can be readily cut apart for filing according to any desired plan.

•

Symposium on Electro-Magnetic Relays. 64 *pages, 8½ by 11 inches, paperbound; available from Potter & Brumfield Mfg. Co. Inc., Princeton, Indiana, on company letterhead request.*

This booklet contains all of the 23 papers given at the Third Annual Symposium on Electromagnetic Relays at Oklahoma Institute of Technology, Oklahoma A & M College, Stillwater, Okla., March 1955.



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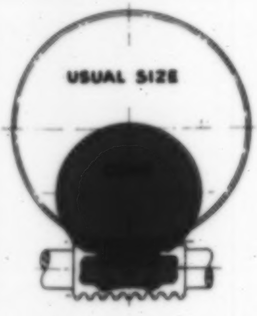

This simple design, with the gear and worm literally "wrapped" around each other, means a space and weight savings that often makes the difference between a compact, efficient product and just another machine.

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Stress Relief

THIS is no short course in psychology. It is an observation by that old sage, J. P. Henderson, on how to get things done.

Being Effective

Whole books have been written about being an *effective* person. I can add little to such wisdom except to quote a friend who recently found such knowledge badly needed among some of his engineers.

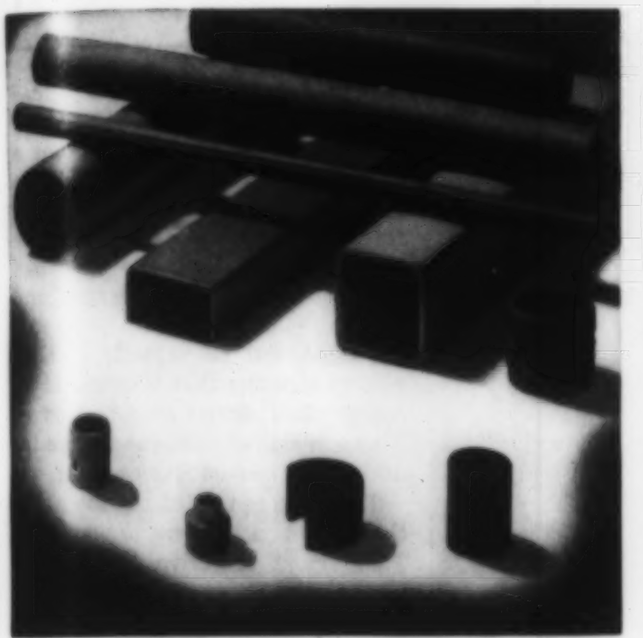
"What can one do, J. P." he said, "with young executives who are supposed to know how to make good use of their time and instead just waste it? How can people be taught to be *effective?* Everytime I stamp out one case, it crops up again in some new form. Maybe I made a mistake in promoting a couple of my men when I did."

The detailed accounts he related to me can be illustrated by one example. It seems that in going past a conference room one morning, he noticed a group assembled with one of his minor executives at the head of the table. An hour later he walked in on the meeting, somewhat curious as to what it was all about. In front of the group was a badly worn gear and a broken shaft. Six engineers were sitting around blowing smoke at the pieces, saying nothing.

It developed that one of their salesmen had been disturbed by a failure, had reported it to this junior executive, and had brought in the broken parts. This salesman, naturally, was somewhat excited about it and he had apparently transmitted his distress to the engineer.

All of the assembled brains had duly examined the parts, contributed their share to the smoke treatment, and had apparently discussed the incident. What had caused the failure? What could they do about it and what were the next steps? This took an hour and, according to my friend, would have been going on still if he hadn't tactfully broken up the meeting.

"Later," said the chief engineer,



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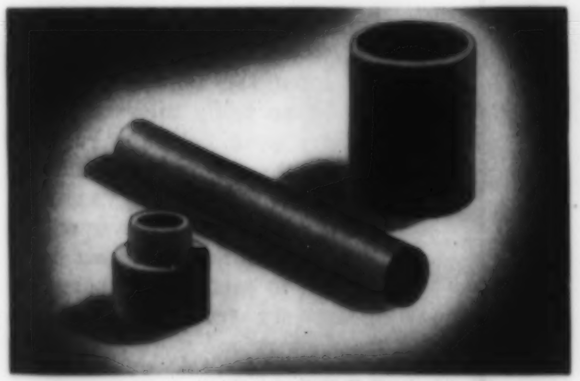

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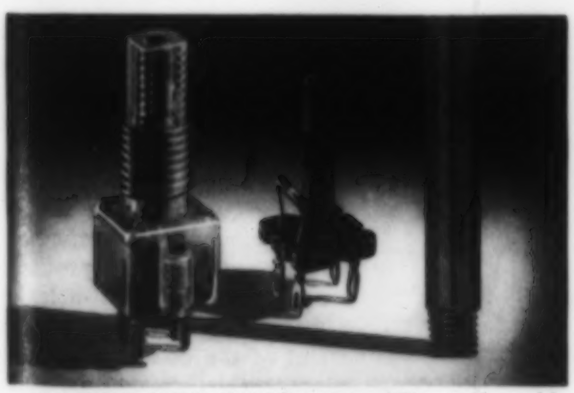
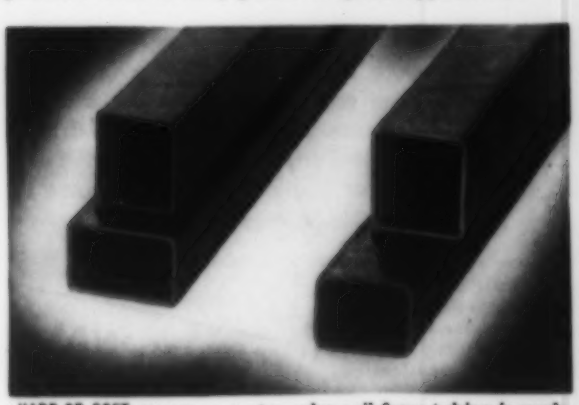
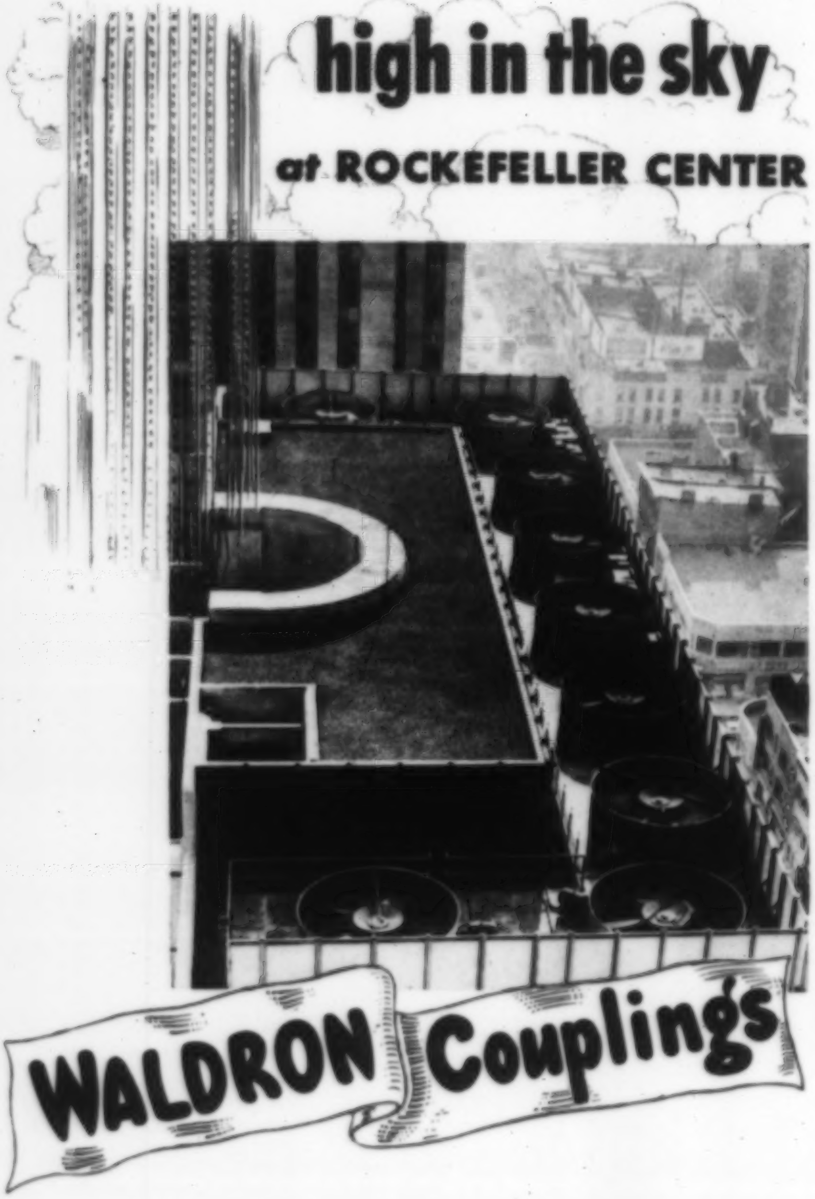


W CONSTANT TORQUE TUBING, for permeability tuning with iron cores, features exact internal threading with three point suspension of the core to prevent binding . . . *no* external embossing to lower dielectric strength. Write for samples.



HARD OR SOFT, square or rectangular coil-form tubing is made for solenoid and transformer applications. Sides are straight with minimum gap in paper winding. Supplied in soft, varnished kraft, or hard, rigid tubing.



Each of the nine PHILLIPS Cooling Towers shown atop this world famous building was equipped with a WALDRON Floating Shaft Coupling to insure trouble-free operation and extra protection against corrosion. The couplings have stainless steel shafts, bolts and nuts and all parts are treated with a zinc base coating and have an iridite finish. Wherever distance between driver and driven equipment presents a problem, a WALDRON Floating Shaft or Spacer Type Coupling will solve it.

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Stress Relief

"I called in Junior and explained some things to him."

First, he knew this was not a new design that had failed, but a unit they had produced in quantity for several years. The evidence therefore was that the unit had undoubtedly been mistreated and was not basically poor.

Second, did he actually and seriously consider that they would redesign their device or any part of it as a result of that one failure inadequately reported by sales?

Third, he reminded the man that they were a *design department*. Their most effective instructions were issued through drawings, fixing a design. If they did not expect a design change as a result of this incomplete study, just what tangible result could he hope for?

It seems that Junior had a defense: Every failure is important. The more they know about such things the better job they could do. Whereupon my friend explained to him further that in calling the meeting he had had no evidence at all as to how the user had treated the unit. Perhaps it had been so badly misused that if the facts were known they would all have thrown up their hands in horror. Why discuss a case in which only *effect* is known with absolutely no real data as to *cause*.

As to each failure being important, my friend reminded Junior that service reports, regularly tabulated, gave such evidence much better than a conference on one case could hope to do.

"Conferences," said my friend, "are terrible things. All sorts of wisecracks and sarcastic definitions are current pertaining to them, but despite all this my youngsters call them at the drop of a hat."

There are a few simple, elementary questions one should ask before planning a conference—or embarking upon any program.

Just what is the problem?

What do you hope to find out?

Out of the possible answers you might obtain, do you expect to be able to do anything effective with the results?

Forethought and planning can save a lot of time.

—J. P. HENDERSON

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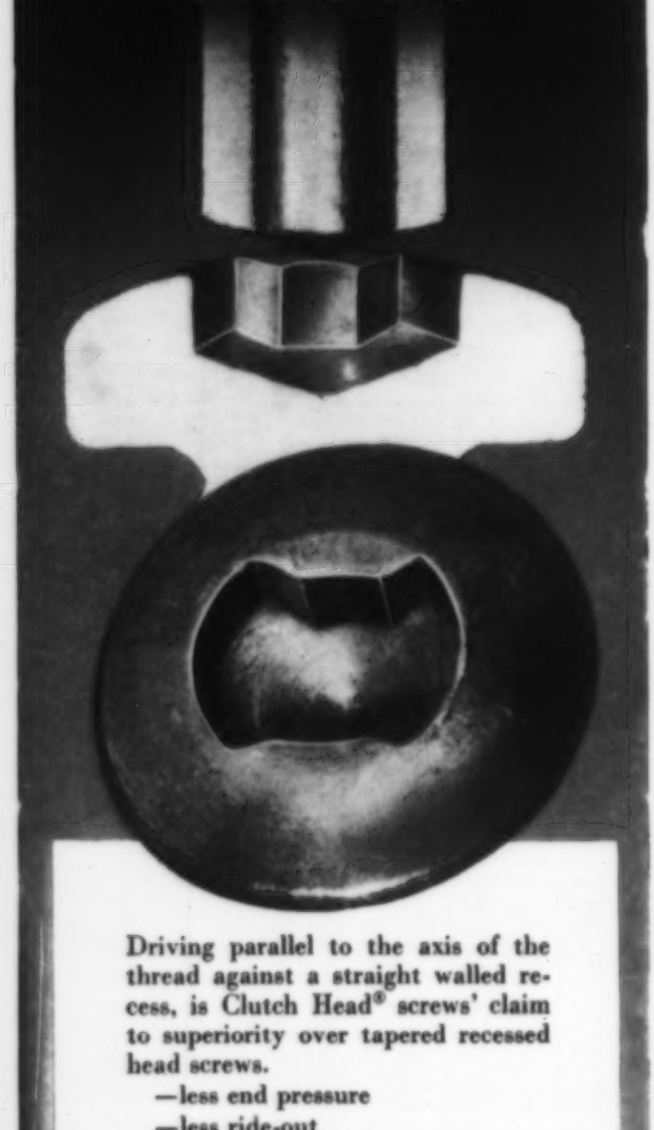

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- —less ride-out
- —reduced screw driver cost
- —plus the use of a common screw driver

are the reasons more and more Companies are using Clutch Head screws.

Write for engineering booklet.

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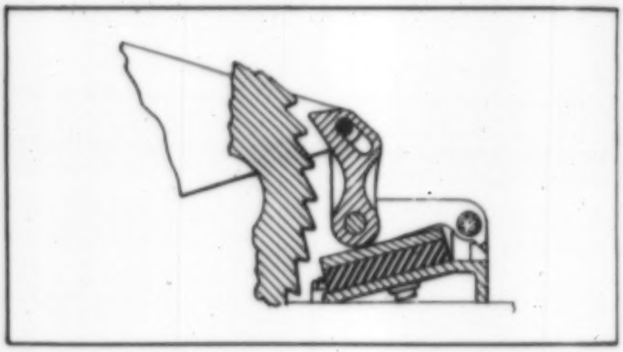
UNITED SCREW and BOLT CORP.
CHICAGO 8, ILL • CLEVELAND 2, OHIO
NEW YORK 7, N. Y.

NOTEWORTHY Patents

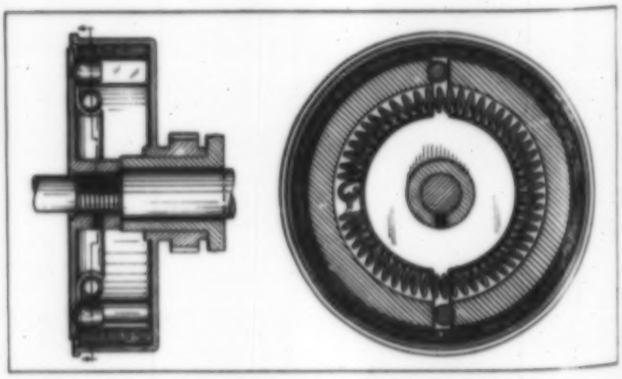
Reverse Rotation Stop

Operation of machinery in one direction only is assured by combining a cam-operated dog with a ratchet wheel. A cage, moved over a limited range by friction between it and the ratchet wheel, carries a pin which engages a cam slot in the dog. In one direction of rotation, the dog is completely disengaged from the ratchet wheel. In the opposite direction of rotation, the dog is positively engaged with the ratchet-wheel teeth to stop rotation. Shock when arresting rotation may be minimized by mounting the dog on a resilient pad. *Patent* 2,687,785 *assigned to Jeffrey Mfg. Co. by P. V. Whitney.*



Shock-Free Centrifugal Clutch

Smooth starting at a predetermined speed is accomplished by a design that permits the clutch shoe elements to engage the driven elements uniformly over their entire contact surface. Semicircular shoes are driven by pins fixed to the driving hub. A garter spring maintains the shoes in a disengaged position when they are not rotating. Encircling the shoes is

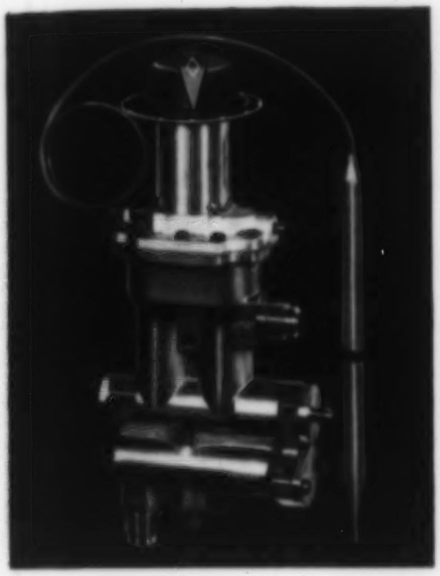


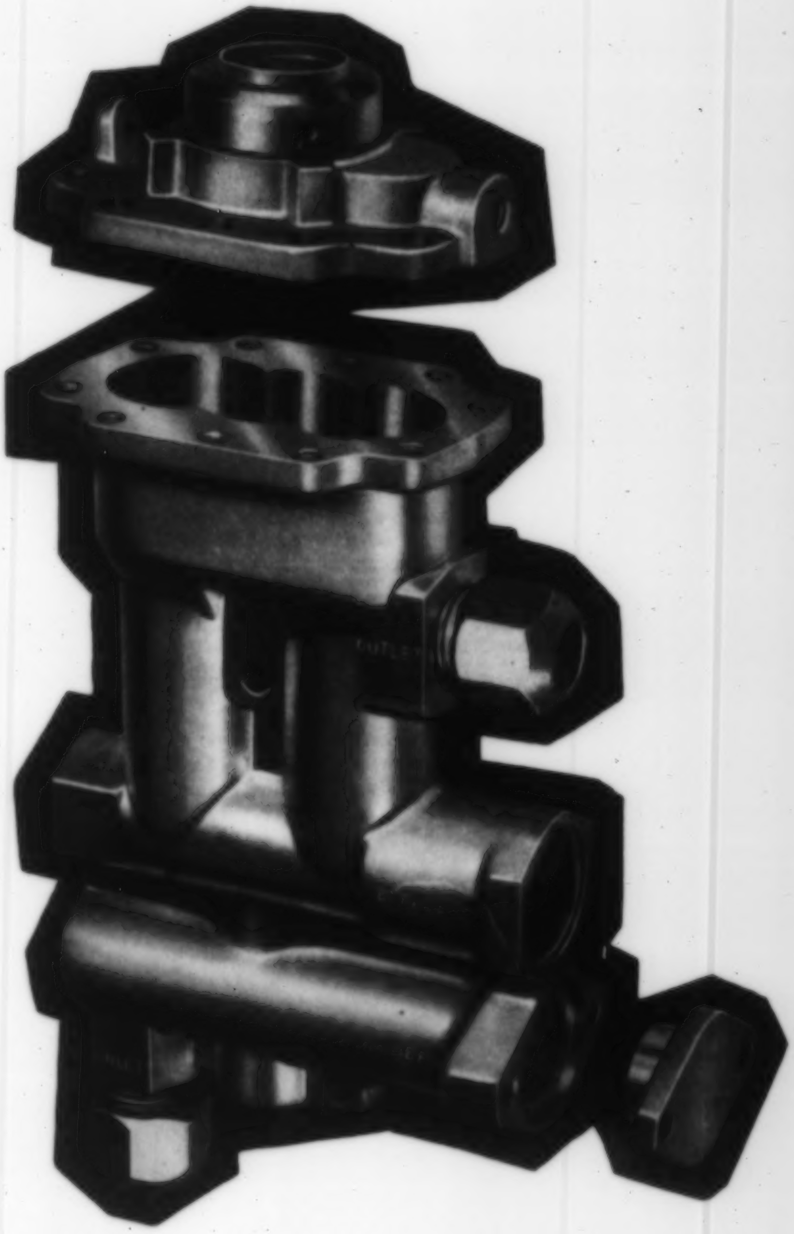
manufacture of

DETROIT SELECTAFLOW CONTROLS

greatly improved by

MUELLER BRASS CO. FORGINGS





One of the finest thermostat control mechanisms for year-around air-conditioning systems is the automatic SELECTAFLOW, a product of the Detroit Controls Corporation. To maintain the high quality of this efficient unit and at the same time speed up and simplify assembly, the body, bonnet and side cover are being forged and completely machined to close tolerances by the Mueller Brass Co. In all, thirty-four machining and finishing operations are performed. This is but one more example of how Mueller Brass Co. machined forgings have improved a product and speeded production. With a wide range of copper-base alloys for forgings, a tremendous background of product engineering, and facilities for precision finish machining, the Mueller Brass Co. can supply machined brass or bronze forgings *to your exact specifications.* It will pay you to consider Mueller Brass Co. forgings for your new or redesigned products. Write us for full color catalog and technical information.

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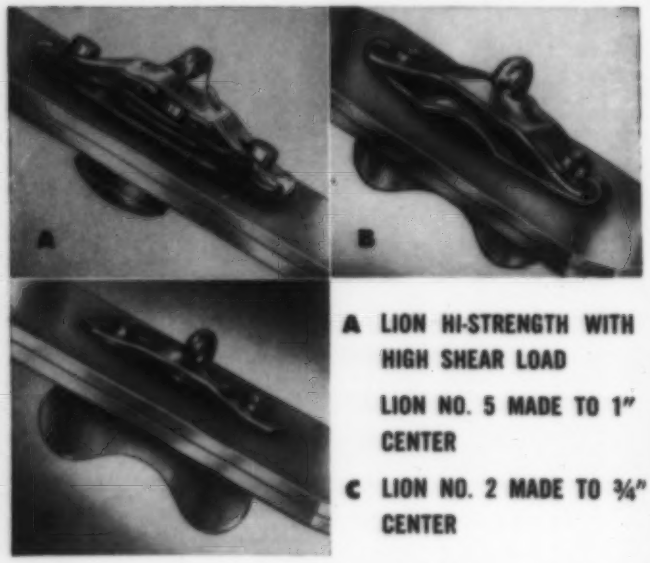
STREAMLINE PRODUCTS

MUELLER BRASS CO.

PORT HURON 15, MICHIGAN

NOW...You can get a quick-acting quarter-turn Lion Fastener for every need!



A LION HI-STRENGTH WITH HIGH SHEAR LOAD

B LION NO. 5 MADE TO 1" CENTER

C LION NO. 2 MADE TO ¾" CENTER

Lion fasteners give you strong, vibrationproof, positive locking for plastic, plywood or metal parts which must be removed repeatedly for inspection, maintenance, etc. Patented Lion cantilever spring locking designs team fast access with absolute safety.

Hi-Strength fastener—takes shear loads up to 4700 lbs. Designed for rugged applications requiring great fastener strength. Takes up no more room than a No. 5 fastener.

No. 5 fastener—recommended for use on panels and inspection doors where long life must be combined with easy access.

No. 2 fastener—used mostly on small panels for electronic telephone and similar equipment. Also frequently used to hold small assemblies which must be removed as units for inspection or service.

Head styles—oval, flush, knurled, ring, notched, wing or to your design specifications.

Delivery—You can be sure of delivery on the date you specify. We stock over one million fasteners in standard sizes and finishes for same day shipment on most orders. Production facilities are almost always open for custom orders.

SEND FOR *FREE* LION DEMONSTRATOR KIT

Tell us the size and type you are interested in seeing, and we will send you a kit in which there is a mounted working model and unmounted components. A request on your letterhead will bring it to you. Write today.

LION *Quarter-turn* FASTENERS

one of the SOUTHCO FASTENERS

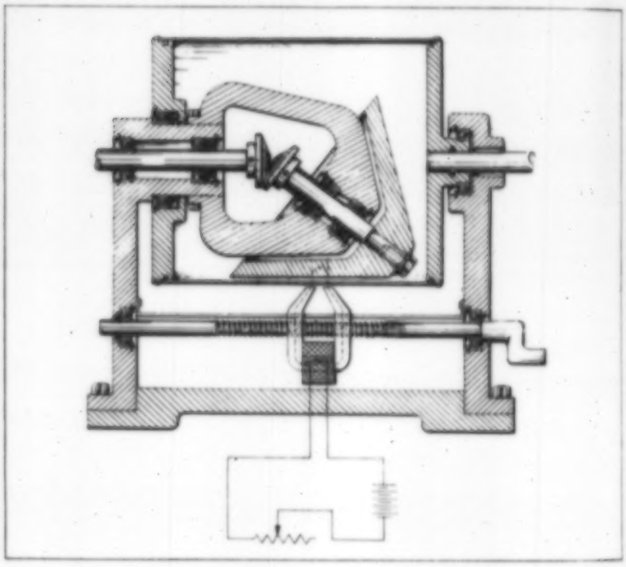
Southco Division
South Chester Corp.
237 Industrial Highway
Lester, Pa.

Noteworthy Patents

a cylindrical brake lining fitted inside the clutch driven member. As the driving member approaches a pretermined rotational speed, the shoes gradually engage the lining until full engagement is reached. *Patent* 2,688,390 *assigned to Development Corp. Inc. by F. S. Thomas Jr.*

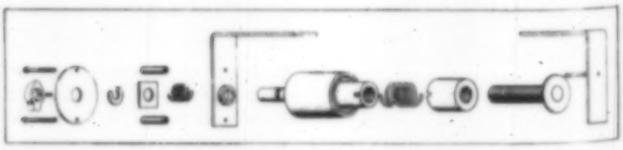
Magnetic Torque Converter

Output shaft speed variations may be obtained without slippage in a magnetic fluid drive by changing the effective ratio between the coupling members. The ratio change is accomplished by magnetizing the magnetic fluid particles between the coupling members at any point along the gap. A movable magnet is positioned along the gap to magnetize the particles. Thus, an infinite number of magnet positions and resulting coupling zones or points are possible. Speed variations along with torque multiplication are possible with this coupling method. *Patent* 2,688,879 *assigned to Vickers Inc. by F. G. Logan and P. H. Trickey.*



Backlash Takeup

Backlash is eliminated in a rotary control shaft by maintaining pressure on opposite sides of the threads of an attached threaded shaft. A portion of the control shaft consists of a hollow chamber made up of a piston loosely fitted into the end of a cylinder. A locking pin prevents rotary motion between the piston and cylinder. Both pieces are drilled and threaded



Monel clamp, precision investment cast by Inco, resists corrosion and erosion in carbon packing ring assembly for Navy steam turbine. Inco precision casting cut production cost 50%.

On this clamp Inco precision casting

saves 8 operations— reduces cost 50%

Drill one hole, and this Inco precision cast Monel clamp is ready for a carbon packing ring assembly.

The assembly is made by Chas. E. Chapin Company of Rutherford, New Jersey. It seals in steam on auxiliary steam turbines for the Navy.

Originally, made by forging and machining, the clamp required eight different operations. *Inco precision casting got rid of all operations except drilling one mounting hole, cut Chapin's production cost 50%.*

Where can you save with Inco precision casting?

Do you have a part which is 6 inches by 5 inches or smaller? Does it weigh under 3 pounds? Require starting tolerances as close as plus or minus .005 inch per linear inch? And need 5 or more fabrication steps? If so, there's a good chance you can cut cost and improve design by having the part precision investment cast by Inco.

Inco precision casts most high-melting point alloys from carbon steel to the new super alloys.

THE INTERNATIONAL NICKEL COMPANY, INC.
67 Wall Street New York 5, N. Y.

5 Advantages of INCO Precision Casting

- Save up to 60% of production costs.
- Longer life with harder alloys.
- Little or no machining required.
- Wider design latitude.
- Higher alloys at lower cost.

Get This Helpful New Booklet

Trying to keep costs in line on some small part? Then write for new 16-page booklet, "Cast to Outlast." Contains many case histories detailing how others cut costs with Inco precision casting. There is a good chance this helpful data will suggest a practical way to cut your costs, too.

INCO
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Inco Castings

Precision · Sand · Centrifugal

this
flexible
metal
hose
Guards
New York's
TV

—another example of how Atlantic's engineers and ingenuity devise new solutions to new problems.

The $1,000,000 tower atop the Empire State building was designed to usher in a new era in TV transmission and reception. Its construction required an unprecedented number of circuits to travel up a tower often of less than two feet square. The conduit, enclosing the cables, had to be extremely *flexible* to avoid splice plates, rivet heads and diagonal braces in the steel work. It had to be permanently weather tight.

Ordinary rigid and flexible metal conduit failed! Atlantic's engineers in cooperation with the RCA Service Co. designed a heavy duty, high pressure bronze hose that did the job and also saved many costly and hazardous man hours of work. This hose was JOB TESTED and CERTIFIED.

Our engineers will help solve *your* problems in weather protection . . . flexibility . . . conveying . . . controlling pressure, movement and vibration . . . correcting misalignments. Seamless and Interlocking Hose. Bronze, Steel, Stainless Steel, Monel. ⅛"-36" I.D. with proper fittings. Write for Bulletin #500. See our Catalog in Sweet's Product Design File.

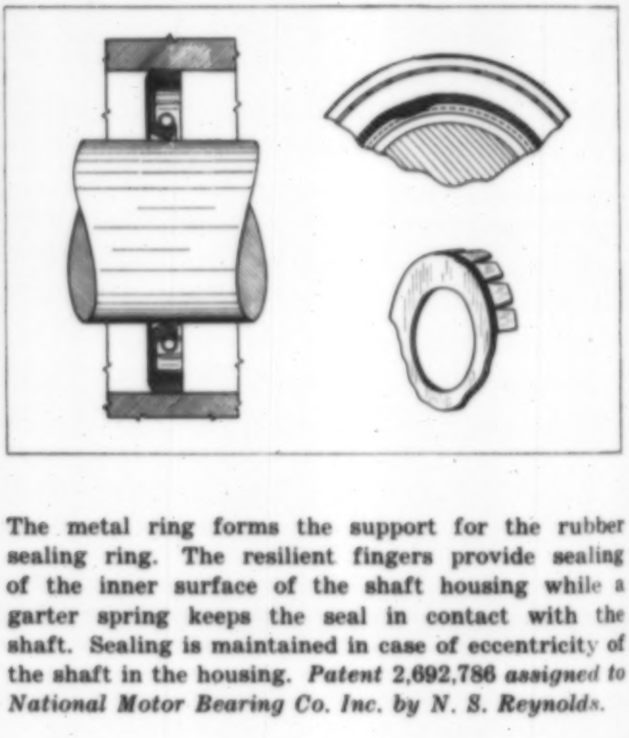
ATLANTIC METAL HOSE CO., Inc.

318 DYCKMAN STREET, NEW YORK 34, N.Y.

on their common axis to receive the threaded shaft. Wrapped around the shaft inside the cylinder is a compressed spiral spring. In operation, the compressed spring forces the chamber halves apart against opposite sides of the shaft threads. As the control shaft is rotated, the cylinder and piston rotate around the threaded shaft while the threaded shaft moves linearily. The device is applicable where a rotary motion must be converted to a linear motion for precision adjustments. *Patent* 2,690,682 *assigned to Collins Radio Co. by H. M. Passman.*

Metal-Reinforced Shaft Seal

Rubber molded to a flat metal ring with resilient fingers makes an effective shaft seal. Easily installed and easily removable, the seal will maintain good sealing engagement even if the rubber takes a set.



The metal ring forms the support for the rubber sealing ring. The resilient fingers provide sealing of the inner surface of the shaft housing while a garter spring keeps the seal in contact with the shaft. Sealing is maintained in case of eccentricity of the shaft in the housing. *Patent* 2,692,786 *assigned to National Motor Bearing Co. Inc. by N. S. Reynolds.*

Patent Abstracts Journal, a weekly English publication, contains abstracts of all new British patents. Abstracts are classified into three groups: (1) General and Mechanical, (2) Chemical, (3) Electrical. Each issue contains a complete name index. Abstracts are published within 10 days of the patents being opened to public inspection. Further information may be obtained by writing Technical Information Co., Patents Dept., Newton House, Mount St., Liverpool 1, England.

Copies of the patents briefed in this department may be obtained for 25 cents each from The Commissioner of Patents, Washington 25, D. C.

Wagner®
ELECTRIC MOTORS
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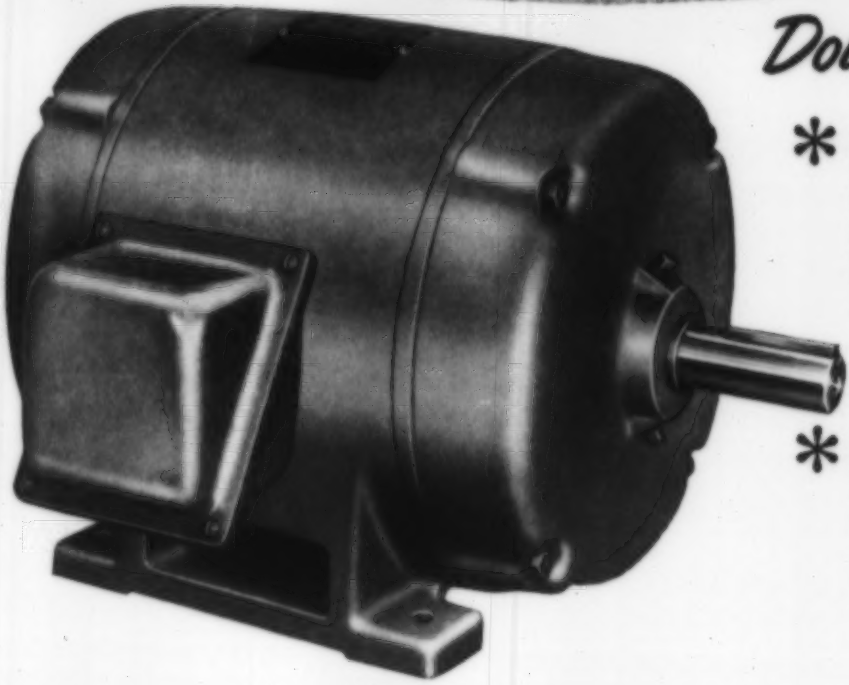
NEW!

Wagner Type DP Motors

Doubly Protected

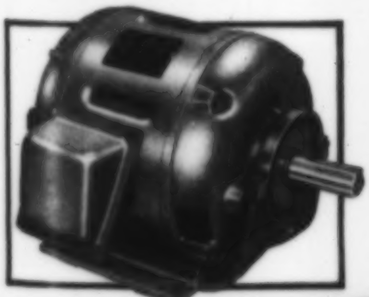


- * Wagner Type DP Motors are protected by rugged, corrosion-resistant cast iron frames, smoothly rounded so that no moisture can collect on them. Motor feet are cast as an integral part of the frame for maximum strength and rigidity.
- * Enclosures are drip-proof plus! Air intakes are located at the bottom of the endplates — air outlets are located at the base of the frame, one on each side. Specially designed baffles provide protection for the stator windings.

The Wagner line of polyphase, drip-proof general purpose motors—rerated to the new NEMA Standards—pack more power into smaller frames, but give you the same high Wagner Quality and long life performance that have made Wagner Motors "the choice of leaders in industry" for many, many years. These new Wagner Motors are fully protected in the ball bearing models. Their construction makes them completely drip-proof — and virtually splash-proof. The extra large, diagonally split conduit box makes wiring easy. Smaller size and lighter weight means more economical handling and installation.

These new rerated Wagner Motors retain the features desired by plant engineers and maintenance men. They will operate for years without regreasing. But . . . when lubrication *is* necessary or desirable, you *can* lubricate these motors because they are provided with two lubrication openings.

Bulletin MU-202 gives full information—write for your copy today.



AVAILABLE WITH RESILIENT MOUNTING —SLEEVE BEARINGS UP THROUGH 5 HP.

These Wagner standard motors, in ratings up through 5 horsepower, can be used for specialized applications because they are available in sleeve bearing models with endplates that will take resilient mounts.

You can look to Wagner for a complete line of standard motors for specialized applications. The wide range of types and sizes permit the selection of a standard motor for almost any need.

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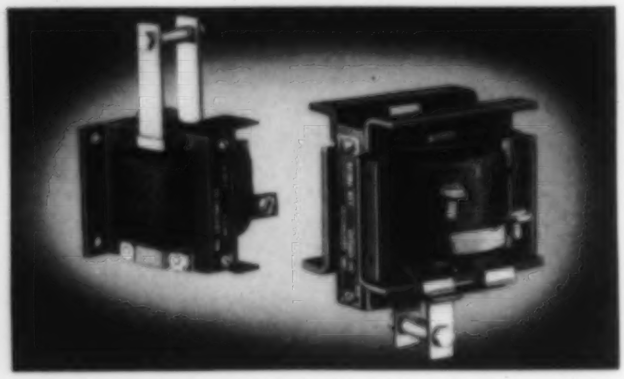
ELECTRIC MOTORS · TRANSFORMERS · INDUSTRIAL BRAKES · AUTOMOTIVE BRAKE SYSTEMS—AIR AND HYDRAULIC

WHAT? **C-H SOLENOIDS**

WHY? **THEY WORK BETTER and last longer**

PROOF? **Long preferred by BIG NAME USERS**



When unfailing dependability is a "must" in such electrically actuated devices as mechanical brakes, clutches, valves, tripping mechanisms, hydraulic pistons, ratchets, etc., insist on Cutler-Hammer Solenoids, Bulletin 10370. They are not ordinary solenoids. They are solenoids built to Cutler-Hammer standards of performance. For many years leading machinery manufacturers renowned for the fine performance and dependability of their machines have specified Cutler-Hammer Solenoids and refused all substitutes.

Cutler-Hammer Bulletin 10370 Solenoids are rated for continuous or intermittent duty. The coils are moisture-resistant, tung-oil impregnated, can be used immersed in non-acid or non-alkaline oil. The coils are held in place by flat steel springs that prevent transmission of shocks to the coils. Plungers and frames are carefully machined to insure quiet operation.

Use Cutler-Hammer Bulletin 10370 Solenoids whenever full rated power straight-line push or pull is required. Plungers are fitted with yoke or clevis connections to the work. Operation may be by a manual switch, pushbutton, pressure switch, float switch, limit switch, etc. Available in many sizes, for floor or wall mounting. Carried in stock by many Cutler-Hammer Authorized Distributors. Phone or write now for full information. Ask about Bulletin 10370. CUTLER-HAMMER, Inc., 1310 St. Paul Avenue, Milwaukee 1, Wisconsin.

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New Machines

Earthmoving

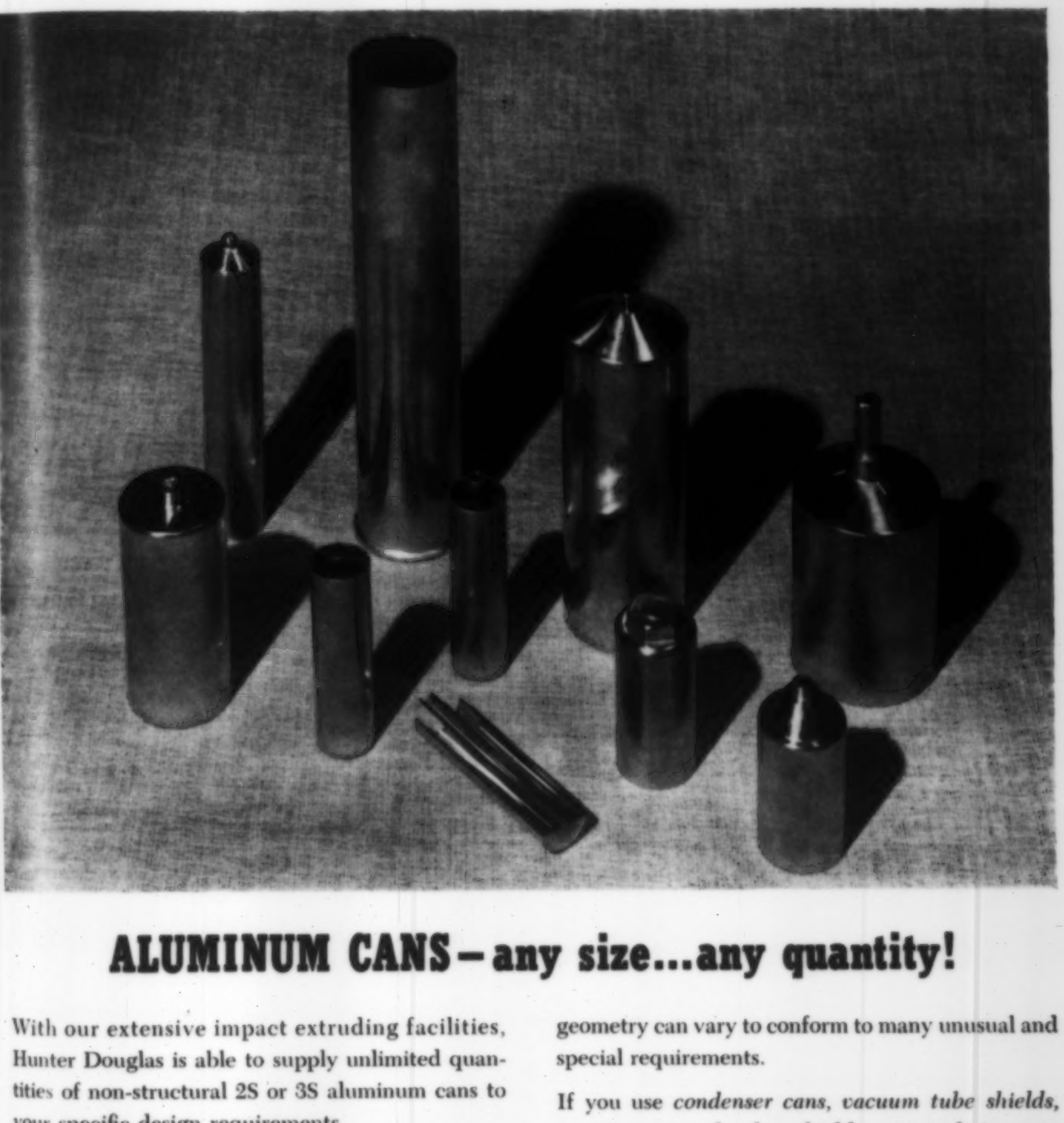
Ditch Digger: Buckeye model 308 pipeline and utility ditcher digs to maximum depth of 66 in. Width of cut is variable from 16 to 32 in. in 2-in. increments. A live hydraulic wheel hoist is used to position the digging wheel. Lowering and raising of the digging wheel is independent of digging, wheel or crawler speeds. Forward and reverse belt drive is provided in a choice of three speeds to meet varying conveyor requirements. Tractor type crawlers have smooth cast treads. A selection of tread pads for specific digging requirements provides varied tread widths and bearing areas. Machine has 16 digging speeds forward, ranging from 0.8 to 19.1 fpm. A separate clutch and separate brake gives independent power to each track. Transmissions are fully enclosed and sealed. *Gar Wood Industries Inc., Wayne, Mich.*

Tractor: Two models of the D8 tractor offer either a torque converter or a direct drive. Available attachments include a rear-mounted double-drum cable control and a front-mounted, single-drum cable control, as well as large bulldozers with six-part lines for great lifting power. Series D, with a three-stage 5:1 torque converter, operates at speeds up to 7.4 mph through a constant mesh transmission which has three speeds both forward and reverse. Direct-drive Series E has five forward speeds and three in reverse, ranging from 1.5 to 5.2 mph. Rated drawbar pull of latter model is 39,150 lb but can be as high as 45,020 lb under certain traction and weight conditions. Drawbar pull of the series D is automatically adjusted to loads within given speed ranges, up to 50,000 lb or more. Design of the hood provides clear visibility on both sides of the tractor. It has seven-roller track frames and 42 track shoes, providing 112 in. of track on the ground. *Caterpillar Tractor Co., Peoria, Ill.*

Materials Handling

Parts Feeder: Large, heavy parts can be positioned as required and fed automatically to all types of packaging and processing machines by model EB-2 vibratory parts feeder. Parts of various shapes and up to 4 in. long can be fed from a 30-in. diameter bowl up and around a spiral track or ramp to single, double or multiple discharge points. The bowl is actuated by an electromagnetic reciprocating motor. Discharge speed is regulated to suit processing requirements by increasing or decreasing the amplitude of vibration. Standard vibrator operates on 110-v, 60-cycle power; other models can be had for 220 or 440-v operation. *Syntron Co., Homer City, Pa.*

Electric Fork Truck: Upright assembly of the Mobil-Mast fork truck, consisting of the mast and lift-



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With our extensive impact extruding facilities, Hunter Douglas is able to supply unlimited quantities of non-structural 2S or 3S aluminum cans to your specific design requirements.

We are at present manufacturing cans of this type in round, square, and other shapes for the electronics industry, and for use in many ordnance components. In addition to the cans pictured, part geometry can vary to conform to many unusual and special requirements.

If you use *condenser cans, vacuum tube shields, transformer and relay shields, pyrotechnic cans, containers—or similar products made from* aluminum, ask for our quotation and prompt delivery schedules! Airmailed or telephoned requests will give quick answers to tight production programs.

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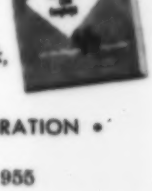
If you want to know more about Hunter Douglas Cold Forgings write on your company letterhead for this free 40 page book, now on the press!



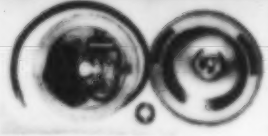
Hunter Douglas Corporation

HUNTER DOUGLAS CORPORATION • DEPT. MD-7 RIVERSIDE, CALIFORNIA TELEPHONE OVerland 3-3030

On Small Gasoline Engines These 3 Fairbanks-Morse Products Are a Must for Dependable Performance and Easy Starting . . .

Your production is simplified with these three products because they are designed for your engine.

FLYWHEEL MAGNETO

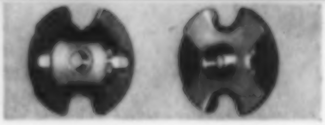


Built by the manufacturer of over 3½ million magnetos it presents a new standard in trouble-free performance and easy starting — molded heavy-duty high tension coil—large, long-lasting breaker points—Alnico permanent magnets—efficient engine performance is assured.

REWIND STARTER

Assures longer life and easier starting. Made principally of die-cast aluminum alloy, this starter is extremely light in weight—50% lighter than other types of starters. There is less pull because the starter engages after only ¼ inch of pull—instead of meshing teeth or pawls, the starter mounts over and engages on a regular rope starter pulley. The pull cord is fray-proof nylon, slim and compact yet will last for the lifetime of the equipment.

CENTRIFUGAL CLUTCH



This clutch is used on a variety of equipment which includes Lawn Mowers, Rotary Tillers, Garden Tractors, Chain Saws, etc. Approximately 80% of all Chain Saws are equipped with our clutch. This is the most rugged clutch application we know of. The Fairbanks-Morse Clutch is resistant to heat and shock which assures long life. The vital parts are tool steel. A wide range of engaging speeds are available because the springs are adjusted to fit the specific application.

Engineering help is yours for the asking—personal, expert attention to your particular problem to assure top operating efficiency and easy starting of your engine is readily available. Write Fairbanks, Morse & Co., Magneto Division, Beloit, Wisconsin.

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ing forks, drive unit and operator's compartment, moves back and forth on channel tracks in the base frame. This movement affords good visibility and rigid load support. Truck's 18-v battery is located so as to act as a counterweight when the lift is at maximum extension and height. Mast unit is locked to the base frame when the truck is being used for operations not requiring extra reach. Truck's capacity is 4000 lb. It can be operated in 6-ft aisles and has three speeds forward and reverse. *Moto-Truc Co., Cleveland, O.*

Stacker: Designed for heavy-duty service, Portelvator model S has load capacity of 3000 lb. Platform operating speed is 58 in. per minute. Platform travel is 41 in., minimum height being 7 in. and maximum height 48 in. Built with six integral rollers, the 20 x 36-in. platform has a hinged cover plate. Electric-mechanical lift is provided by a 3-hp crane hoist type motor. *Hamilton Tool Co., Hamilton, O.*

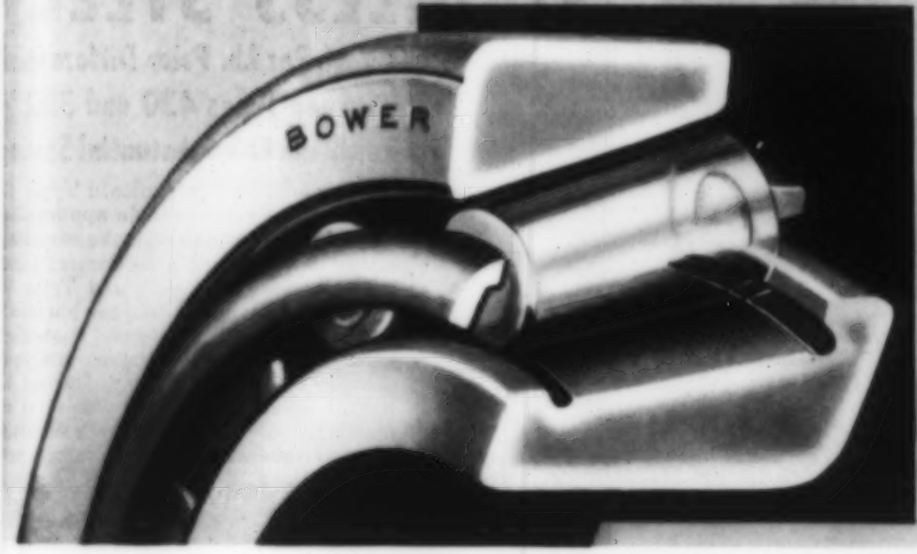
Metalworking

Shaping Machines: Two Shear-Speed shapers, models 18136 and 18206, produce gears up to 20 in. in diameter and up to 6-in. face width. Time required to cut such a gear is 13 minutes. Since all teeth of a gear or other external contour are cut simultaneously, splines, ratchets, clutches and cams are formed rapidly and efficiently. One operator can control the 44-ton, 17-ft high machine. An automatic hydraulic positioning hoist is used to swing the cutting head into position for mounting in the machine, and also to load and unload part blanks that weigh up to several hundred pounds. Components are easily accessible for maintenance. Chip removal is accomplished by built-in conveyors. Three automatic pressure lubricating systems feed a continuous flow of oil to all moving parts. Either hydraulic or pneumatic automatic clamping fixtures can be used. Operation of the clamping fixture is co-ordinated with the completely automatic machining cycle. Complete tool changeovers can be accomplished in 25 to 45 minutes. *Michigan Tool Co., Detroit, Mich.*

Cam Grinder: No. 3 Cam-O-Matic automatic cam grinder has a positive work drive, employing a Gilmer timing belt to provide smooth work rotation. Machine has two automatically controlled work speeds. The higher speed is adjustable for optimum rate of stock removal; the slower speed provides contour accuracy and fine finish. Changeover from fast to slow speed is automatic, and timing is readily adjustable. A heavy, one-piece rocking bar with large cross-sectional area is supported at the center by a tapered roller bearing. Wheel guard truing and compensation for wheel wear are automatic. *Norton Co., Worcester, Mass.*

Production Press: New 100-ton press is 7 ft high and occupies approximately 44 sq ft of floor space. It has a four-speed operating control mechanism, providing 40, 50, 60 or 80 strokes per minute. Area of the bed and clearance are large in relation to the tonnage. Complete clearance is provided between the

Bower spher·o·honed design provides better bearing lubrication



LARGE OIL GROOVE GIVES POSITIVE LUBRICATION TO ROLLER HEADS

The large oil groove built into Bower Spher-O-Honed bearings is just *one* of several important Bower design features which reduce maintenance and increase efficiency. Combine it with generated spherical roll-heads and a higher flange surface, and smooth, precision-honed races, and you have the basic elements of Spher-O-Honed design.

A careful look at the illustration above will show you other important Bower features, too. Note particularly that the roller heads contact the flange over a wide two-zone area—thus reducing wear and minimizing resultant "end play."

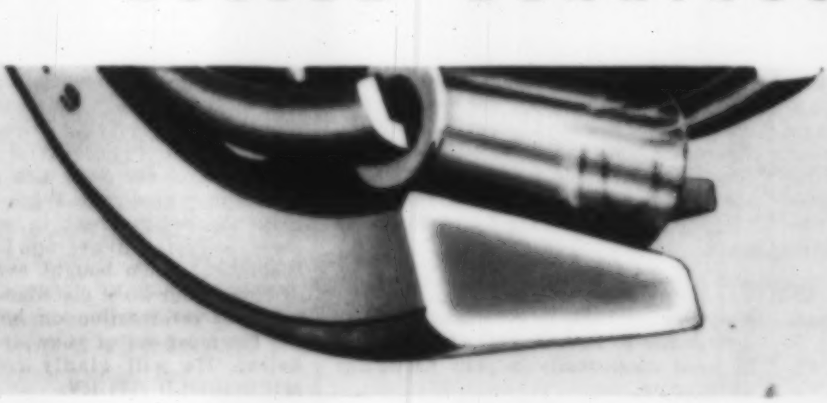
Built of the highest quality materials and workmanship, Bower bearings are available in a complete range of sizes and types to meet your present requirements. Call in a Bower engineer now!

BOWER ROLLER BEARING COMPANY • DETROIT 14, MICHIGAN

BOWER

ROLLER BEARINGS

SPHER-O-HONED



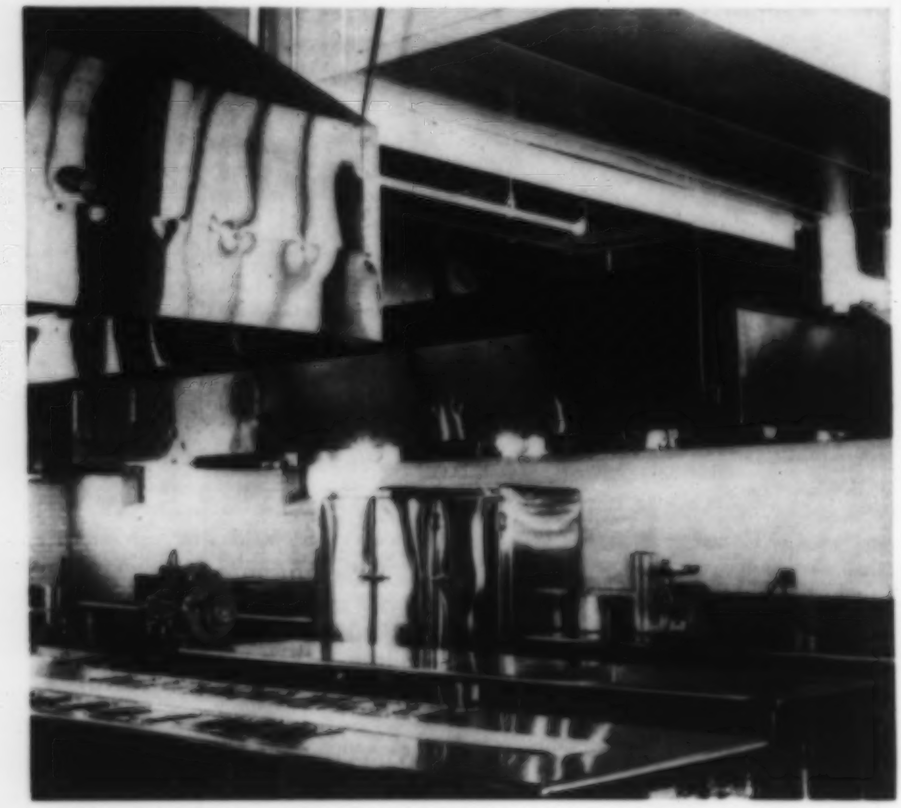
A COMPLETE LINE OF TAPERED, STRAIGHT AND JOURNAL ROLLER BEARINGS

Washington Steel News

PUBLISHED BY WASHINGTON STEEL CORPORATION, WASHINGTON, PA.

Stainless Steel Buyers:

SAVINGS OF $145 PER TON NOW POSSIBLE WITH *MicroRold*® STAINLESS STEEL



TYPICAL INSTALLATION OF MICROROLD TYPE 430—This Kitchen and Bakery Building of the South Carolina State Hospital, Columbia, S.C., is the largest institutional combined kitchen and bakery in the southeast. 18 gauge Type 430 stainless steel is used extensively in 17 exhaust and equipment hoods. They are designed for strength, appearance, and sanitation and were fabricated by Earl DeLay & Co. of Columbia, S. C.

7¼¢ Per Lb. Price Differential Between Types 430 and 302 Results in This Substantial Savings

By specifying MicroRold Type 430 stainless steel for suitable applications, stainless steel buyers can take advantage of the 7¼c per pound difference in base price between Type 430 and Type 302 stainless. A saving of $145 per ton merits consideration. Type 430 is a straight chromium-stainless with a nominal composition of 17% Chromium. During the Korean conflict, Type 430 was used extensively, due to government restriction on nickel-bearing stainless.

WIDE USE FOR TYPE 430

While Type 430 does not possess the same degree of corrosion resistance as Type 302, it has proven very satisfactory in a wide range of mild corrosion applications, both interior and exterior. It lends itself to a multitude of decorative and functional uses, combining all the advantages and qualities of stainless steel — beauty, strength, corrosion resistance, long life, workability and ease of maintenance. Considering the price advantage, with no sacrifice in quality when applied properly, stainless steel buyers will find MicroRold Type 430 a worthwhile material for an impressive number of stainless steel applications.

EXTRA SAVINGS

Washington Steel Corporation not only points out the savings and advantages that may be acquired through the selection of Type 430, but also the significant economies in its production of all stainless types. Special production equipment and methods produce controlled accuracy of gauge throughout length and width of the entire sheet; thus, MicroRold may be specified by decimal thickness (with tolerances as low as 3% average) instead of gauge number. By specifying MicroRold sheet rolled to the light side of the gauge range, purchase costs are reduced by the savings in weight. While this saving may not be apparent in every single sheet, weights will average less than the theoretical when bought over a period of time. **Your steel distributor can give you full information on how you can get the most out of your stainless steel dollar. He will gladly tell you the MICROROLD STORY.**

Type 430 Satisfactory For Mild Corrosion Applications

This straight chromium-stainless grade possesses desirable properties that recommend it for a diversity of applications under general atmospheric conditions. It is non-hardenable by heat treatment and is only mildly hardenable by cold working. It has moderate ductility, good forming and bending characteristics and can be drawn to a moderate degree.

Brazing and soldering are easily accomplished, and except where resistance to high stresses is a major factor, it welds satisfactorily by the usual methods. Before fabricating MicroRold Type 430, it is advisable to consult our mill or distributor to make certain that it may be used successfully in your particular application.

Type 430 Good Insurance Against Shortage Of Nickel Types

Any restriction or curtailment of nickel-bearing stainless (as during the Korean Engagement) could have serious effect upon stainless steel fabricators. By making use of Type 430 wherever feasible, stainless fabricators can insure themselves against any unforeseen developments in the supply of stainless steel.

posts from front to back and right to left. Drive mechanism is housed in the base and pulls the head down, eliminating overhead thrust and assuring alignment by both punch and die. Press also has a forced-feed lubricating system, herringbone back gear and an air clutch. *Alpha Press and Machine Inc., Detroit, Mich.*

Production Lathe: Hi-Turn 10-in. capacity lathe is rated at 5 hp. No leadscrew is employed in this design. A feed rod provides for turning, boring and facing operations. Nine spindle speeds range from 136 to 3000 rpm; nine feed rates range from 0.0015 to 0.024-in. per revolution. Lathe has a totally enclosed quick-change gear box, a built-in four-way tool block with provision for rear and multiple-tool operation, dual direct-reading micrometer cross-feed dial reading to 0.001-in. on diameter, automatically operating template type length stops, and hardened and ground taistock spindle. Headstock has all spur gearing; built-in lubricating pump, filter and reservoir; and built-in ammeter which shows horsepower consumption. All control buttons are on the headstock. *Lodge & Shipley Co., Cincinnati, O.*

Press Brake: Designed for shallow draw work and various types of press operation, new press brake has 36-in. permanently wide bed and ram with 15-in. shut height and 8-ft overall die surface. Six 12-in. air cushions are mounted on the underside of the bed in both the front and back. Machine is equipped with an air-electric clutch with automatic stop and nonrepeat mechanism. Two foot pedals, arranged to operate as one unit, also can be operated separately. A two-speed transmission operates at 13 and 30 strokes per minute. Stroke length is 5 in. *Cincinnati Shaper Co., Cincinnati, O.*

Processing

Rubber Molding Press: Ten-opening, hydraulic platen press for the production of molded cellular rubber products has 1100-ton capacity. Press can also be used for general purpose rubber processing operations such as curing slab stock and producing floor tile. Platen size is 42 x 42 x 2½ in. The machine is elevator fed and can be used with an accumulator system or a self-contained pumping unit. It is 14 ft high, 5 ft wide and 4 ft deep. *R. D. Wood Co., Philadelphia, Pa.*

Heat-Treating Furnace: Using a protective atmosphere for general hardening and carburizing, a new furnace leaves steel clean and free from decarburization. The atmosphere system consists of a cracking unit to which a variable-speed pump feeds a mixture of alcohol and water proportioned according to the type of treatment desired. The mixture is cracked into gas of a controlled analysis to maintain the correct carbon potential for equilibrium with the steel being treated. An Inconel retort which has a welded thermocouple well and a welded pipe extension to provide for gas admission provides a complete seal. Chamber dimensions are 8 x 6 x 14 in., and the power rating is 4.8 kw at 230 v. *Cooley Electric Mfg. Corp., Indianapolis, Ind.*

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